

Satellite Observations of Water Quality for Sustainable Development Goal 6



GEO Week 2017, October 24, 2017

Course Objectives

At the end of this session you will obtain:

- information about monitoring coastal and inland water quality using satellite observations that can contribute to the United Nations Sustainable Goal 6.3, related to availability of clean water
- a basic understanding about developing water quality monitoring applications using satellite observations and in situ measurements for your region of interest
- a hands-on exercise for accessing and analyzing selected water quality indicators for Harmful Algal Blooms (HAsB), e.g. chlorophyll-a concentration (Ch-a) and sea surface temperature (SST)



Agenda

- Overview of:
 - Applied Remote Sensing Training (ARSET) Program
 - The UN Sustainable Development Goal (SDG) 6
 - Satellite Data Products for Water Quality (WQ) Monitoring
 - For SDG 6.3.2: Proportion of bodies of water with good ambient WQ
- Examples of Monitoring Harmful Algal Boom Indicators
- Demonstration of Web-based Tools for Water Quality Data Access
- Hands-on Exercise to Access Chl-a and SST Data over the Great Lakes
- Break-out Groups: Discussion on Data Needs for WQ Monitoring and Decision Support



Applied Remote Sensing Training (ARSET)

Speaker: Elizabeth Hook

NASA's Applied Remote Sensing Training Program (ARSET)

<http://arset.gsfc.nasa.gov/>

- Empowering the global community through remote sensing training
- Part of NASA's Applied Sciences Capacity Building Program
- Goal: increase the use of Earth Science in decision-making through training for:
 - policy makers
 - environmental managers
 - other professionals in the public and private sector
- Trainings offered focusing on applications in:



Air Quality



Disasters



Land



Water Resources

ARSET Team Members

Program Support

Ana Prados, Program Manager (GSFC)

Brock Blevins, Training Coordinator (GSFC)

David Barbado, Spanish Translator (GSFC)

Annelise Carleton-Hug, Program Evaluator
(Consultant)

Bryan Duncan, Program Support (GSFC)

Elizabeth Hook, Technical Writer/Editor (GSFC)

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Acknowledgement:

We wish to thank Nancy Searby for her
continued support

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Erika Podest, Instructor (JPL)

Land & Wildfires

Cynthia Schmidt, Lead (ARC)

Amber Jean McCullum, Instructor (ARC)

Health & Air Quality

Pawan Gupta, Lead (GSFC)

Melanie Cook, Instructor (GSFC)

ARSET Training Levels

Advanced Training, Level 2

- Advanced Webinars Using NASA
- Requires Sensing for Flood Management knowledge
- More in-depth or focused topics

Beginning Training, Level 0

- NASA Remote Sensing Observations for Flood
- Requires level 0 training or equivalent knowledge
- Specific applications

Fundamentals Training, Level 0

- Fundamentals of Remote Sensing
- Satellites, Sensors, Knowledge Systems/Tools for Water Resource Management

ARSET Trainings



96 trainings



11,500+ participants



150+ countries



2,500+ organizations

General/Train the Trainers

Water Resources

Land

Disasters

Air Quality & Health

2012

2013

2014

2015

2016

2017

* size of bubble corresponds to number of attendees



Example: Introduction to Remote Sensing for Coastal and Ocean Applications

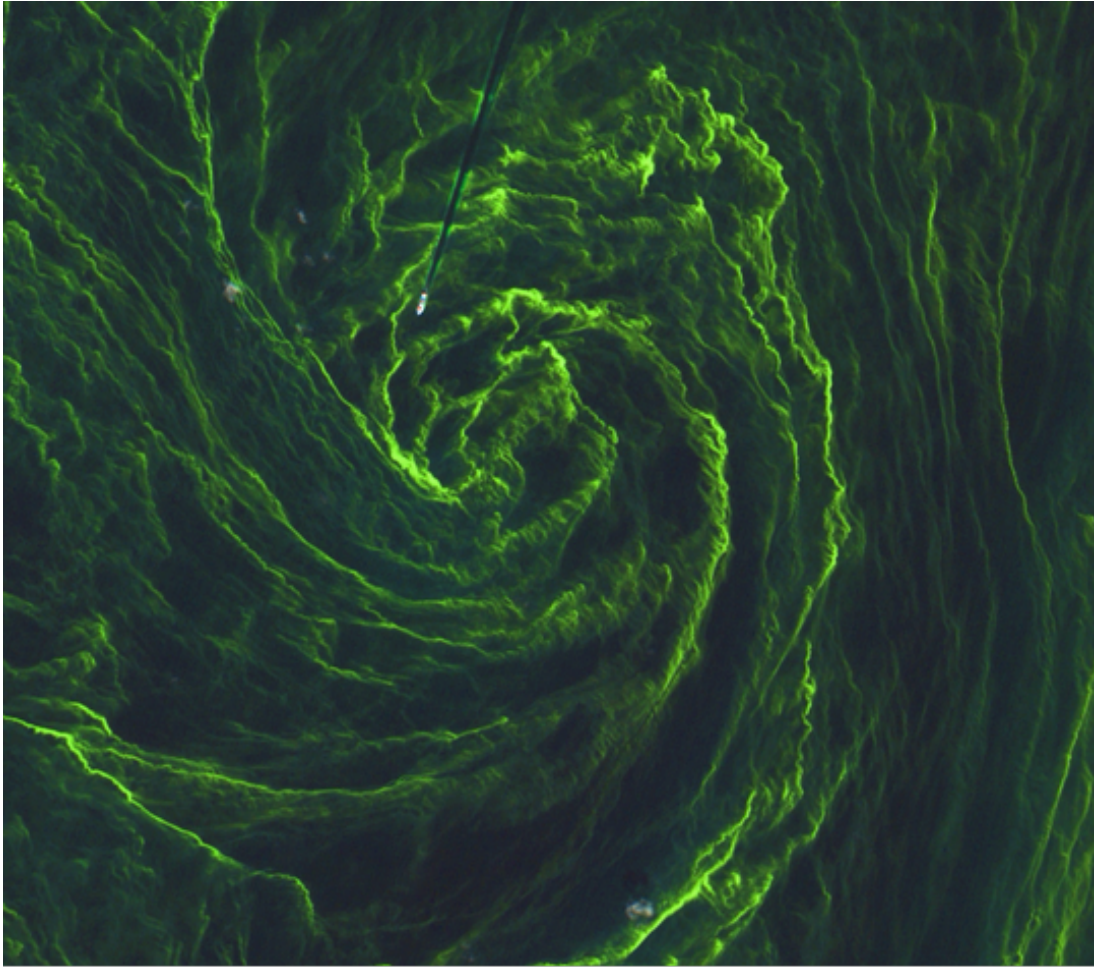


Image Credit: Copernicus Sentinel data (2015)/ESA, CC BY-SA 3.0 IGO

- Designed to provide participants with
 - an overview of aquatic remote sensing
 - data access and tools for processing and analyzing imagery
 - examples and live demonstrations of applied science tools developed for NASA and partner organizations
- Learning Objectives:
 - understand remote sensing in aquatic environments
 - access and visualize relevant NASA Earth Science data
 - understand techniques for using NASA Earth Science data in the areas of animal migration and coral reef health

Sign up for the ARSET Listserv

<https://lists.nasa.gov/mailman/listinfo/arset>



As the weather warms in the Northern Hemisphere, many will notice an increase in algal blooms like [this one](#) which occurred in Washington last year. [Learn the basics of aquatic remote sensing, including how to access satellite-derived chlorophyll data.](#)

UN Sustainable Development Goals

In the 2030 Agenda for Sustainable Development, the United Nations established a series of goals for protecting the planet and ending global poverty. In a recent ARSET webinar, nearly 400 participants learned to use satellite observations of air quality in support of the goals. The training was featured on the [SDG Knowledge Hub](#), and materials from the training are now available on the [ARSET website](#). This June, the program is offering a three day webinar on remote sensing of land indicators for Sustainable Development Goal 15.

[Register Here](#)

NASA EOSDIS recently announced that Reverb data search would be replaced with Earthdata Search by the end of the year. The new system will be faster and easier to use. [Read the full announcement here»](#)

Remote Sensing of
Aquatic Environments



Introduction to Synthetic Aperture Radar Introducción al Radar de Apertura Sintética

June 28, 29 and July 5, 6
English: 21:00-22:00 EDT (UTC-4)

SAR can observe the Earth's surface day and night, through most weather conditions, and the signal can penetrate the vegetation canopy. There are a number of existing SAR datasets from current and past airborne and satellite missions, as well as exciting upcoming missions. This online webinar will focus on building the skills needed to acquire and understand SAR data, including polarimetric and interferometric SAR (PolSAR and InSAR), as well as potential applications.

[Register](#)

28, 29 de junio y 5, 6 de julio
Español: 12:00-13:00 EDT (UTC-4)

SAR puede observar la superficie terrestre de día y de noche y a través de la mayoría de las condiciones meteorológicas. Además, la señal puede penetrar la cubierta vegetal y proporcionar información relacionada al estado de inundación de la vegetación. Existen datos de SAR del presente y del pasado obtenidos desde satélites y aviones y habrá más con futuras misiones. Esta capacitación en línea se enfocará en desarrollar los conocimientos necesarios para adquirir y entender datos de SAR incluyendo polarimetría e interferometría y sus potenciales aplicaciones.



The MODIS image above (Credit: [NASA Earth Observatory](#)) shows a wildfire burning in Greenland. Many areas around the world are experiencing above average wildfire activity this year. [Learn to forecast, monitor, and manage wildfires using satellite observations.](#)

SAR Success

We just wrapped up our first training focused on Synthetic Aperture Radar. Unlike optical sensors, SAR can penetrate through cloud cover and vegetation and is useful for nighttime observations. This four-session webinar, offered in both English and Spanish, was ARSET's largest training to date. Missed the live webinar? You can watch it on demand.

[Watch Now](#)

Have You Heard of AppEEARS?

Application for Extracting and Exploring Analysis Ready Samples, or AppEEARS, is a useful tool for downloading remote sensing data. Download just the data you need by subsetting spatially (by point or area), temporally, and spectrally. The application also allows you to visualize the results before downloading them.

[Learn More](#)





Information about SDGs and SDG 6

Speaker: Brock Blevins

UN Sustainable Development Goals

Transforming Our World: The 2030 Agenda for Sustainable Development

- A plan of action for people, planet and prosperity
- All countries and all stakeholders, acting in collaborative partnership, will implement this plan
- 17 SDGs and 169 targets
- Balance the three dimensions of sustainable development:
 - economic
 - social
 - environmental



Reference: [Transforming our world: the 2030 Agenda for Sustainable Development](#)



SDG 6: Clean Water & Sanitation Targets

Ensure Availability and Sustainable Management of Water and Sanitation for All

6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

6.3: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

6.5: By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

6.a: By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

6.b: Support and strengthen the participation of local communities in improving water and sanitation management



SDG 6: Clean Water & Sanitation Indicators

Ensure Availability and Sustainable Management of Water and Sanitation for All

6.1.1 Proportion of population using safely managed drinking water services

6.2.1 Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water

6.3.1 Proportion of wastewater safely treated

6.3.2 Proportion of bodies of water with good ambient water quality

6.4.1 Change in water-use efficiency over time

6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

6.5.1 Degree of integrated water resources management implementation (0-100)

6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation

6.6.1 Change in the extent of water-related ecosystems over time

6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan

6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management



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SDG 6.3

- By 2030, **improve water quality** by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
- 6.3.1: Proportion of wastewater safely treated
- **6.3.2: Proportion of bodies of water with good ambient water quality**



6.3.2: Proportion of Bodies of Water with Good Ambient Water Quality

- Data collected by UNEP every 3-4 years
- Resources specific to this indicator: <http://www.sdg6monitoring.org/news/indicators/632>

“Although limited to only a few water quality parameters and larger rivers and lakes, satellite-based remote sensing could support monitoring for indicator 6.3.2 in areas lacking traditional, ground-based water quality monitoring”

monitoring sdg 6 on water and sanitation

HOME NEWS ABOUT WHY HOW INDICATORS FAQ RESOURCES CONTACT SEARCH



Indicators, Resources · 6.3.2, Water quality, Guide, Methodology, 6.3

Monitoring ambient water quality (indicator 6.3.2)

INDICATOR 6.3.2 "PROPORTION OF BODIES OF WATER WITH GOOD AMBIENT WATER QUALITY"

The indicator tracks the percentage of water bodies in a country with good ambient water quality. "Good" indicates an ambient water quality that does not damage ecosystem function and human health according to core ambient water quality parameters.

Overall water quality is estimated based on a core set of parameters which inform on major water quality impairments present in many parts of the world. For surface water, these parameters are dissolved oxygen, electrical



Target 6.3 sets out to improve ambient water quality - this page explains why and how to monitor progress towards the target, and what resources that are available for countries to do so



6.3.2: Proportion of Bodies of Water with Good Ambient Water Quality

Further support:

- GEMI: Part of the UN-Water Integrated Monitoring Initiative tasked with integrating and expanding existing monitoring efforts for SDG Targets
- <http://www.sdg6monitoring.org/news/presenting-gemi?rq=gemi>



Other ARSET Trainings Related to SDG 6



Remote sensing can be used to monitor and address a variety of issues related to water resource management, including drought, flooding, and reservoir management

Relevant Targets:
6.3, 6.4, 6.5, 6.6,



Level 0

Fundamentals of Remote Sensing for Water Resource Management

<http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing#water>

1 Hour



Level 1

Water Resource Management Using NASA Earth Science Data

<http://arset.gsfc.nasa.gov/water/webinars/water-resources15>

5 Hours



Level 1

Applications of Remote Sensing to Soil Moisture & Evapotranspiration

<http://arset.gsfc.nasa.gov/water/webinars/apps-et-smap>

5 Hours





Satellite Data Products for Water Quality Monitoring

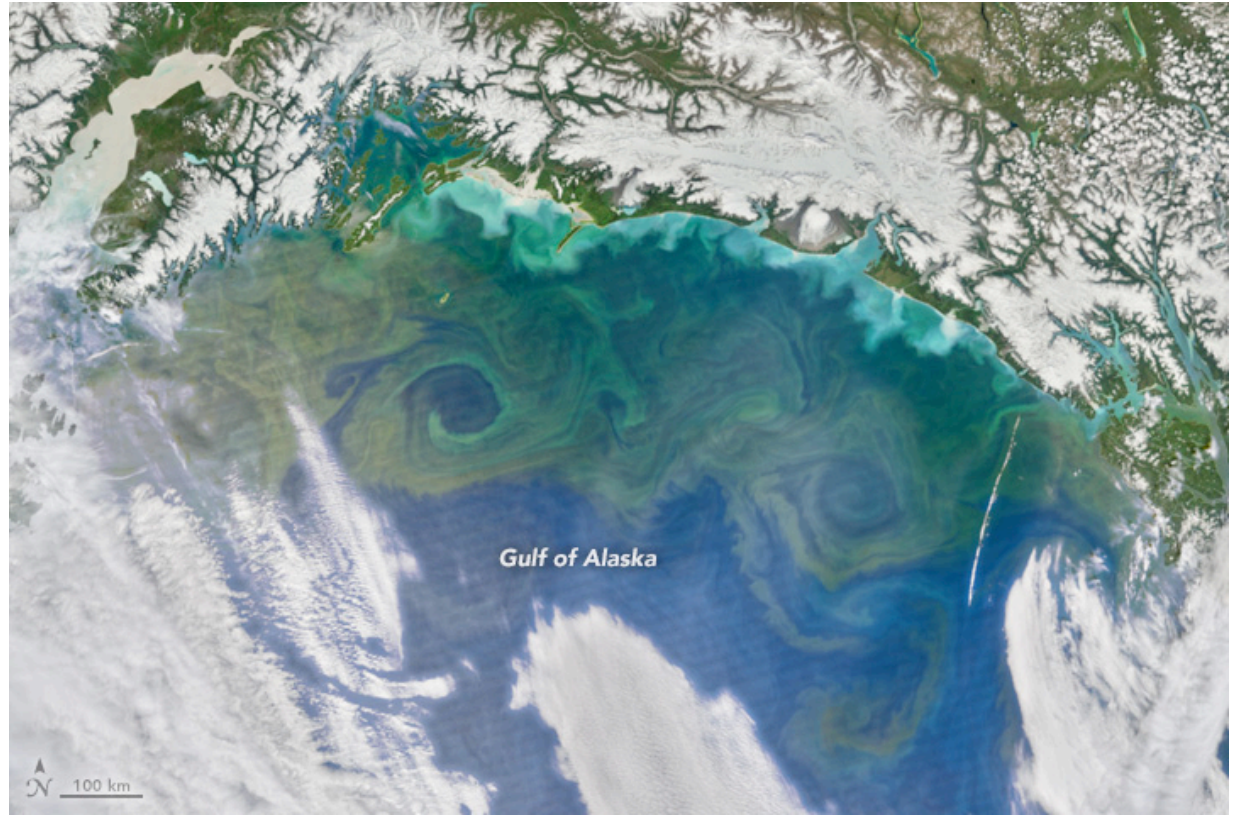
Speaker: Amita Mehta

WQ Indicators Observable from Satellites

- Turbidity / Sediments
- Colored Dissolved Organic Matter (CDOM)
- Sea Surface Temperature (SST)
- Chlorophyll-a (phytoplankton)
- Salinity

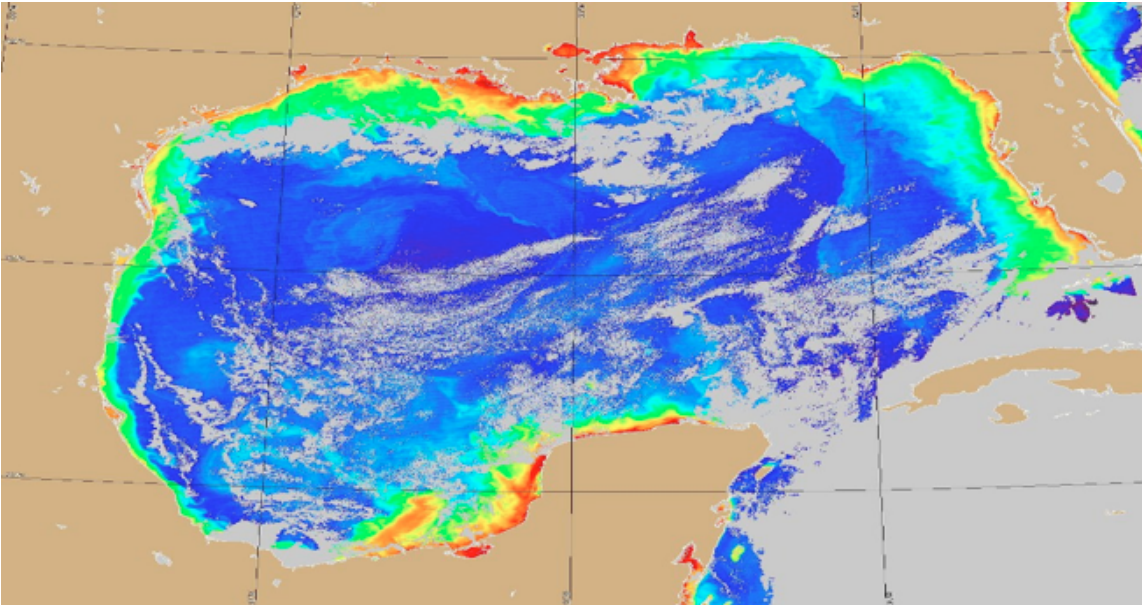
Phytoplankton Bloom in the Gulf of Alaska

SNPP-VIIRS June 9, 2016



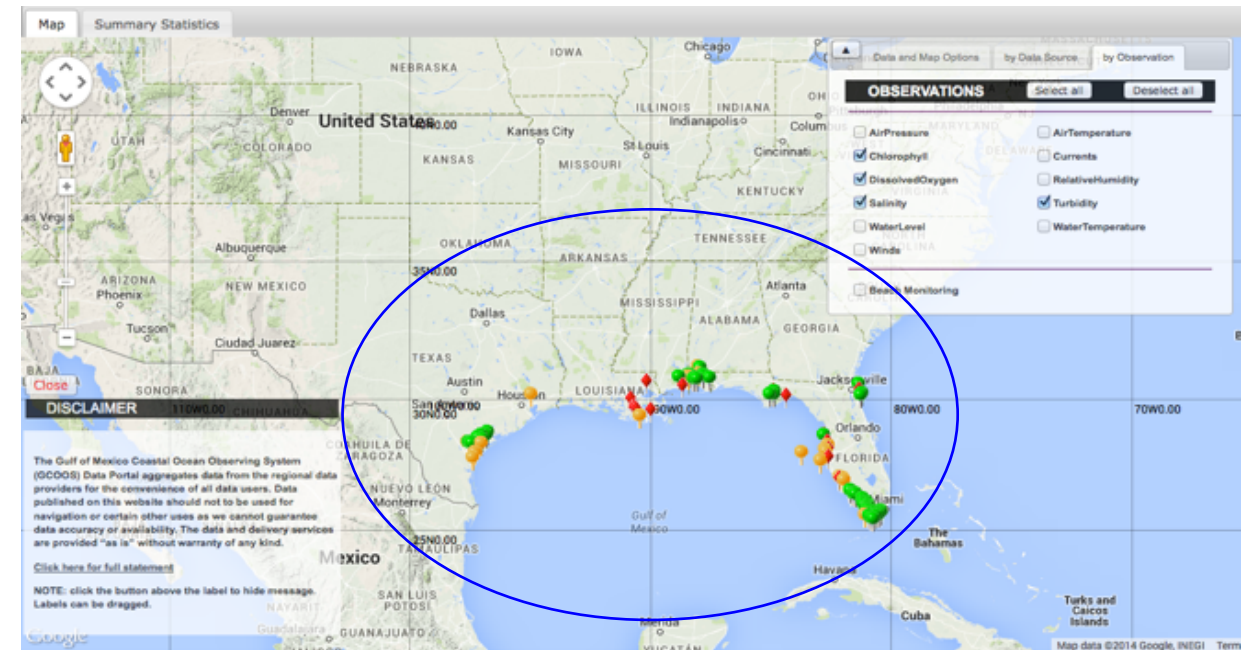
Advantage of Satellite Observations for Water Quality Monitoring

- Provides information where there are no surface-based measurements available
- Global and near-global coverage with consistent observations
- Continuous coverage in comparison to point measurements



Limited Water Sampling Locations

<http://data.gcoos.org/>

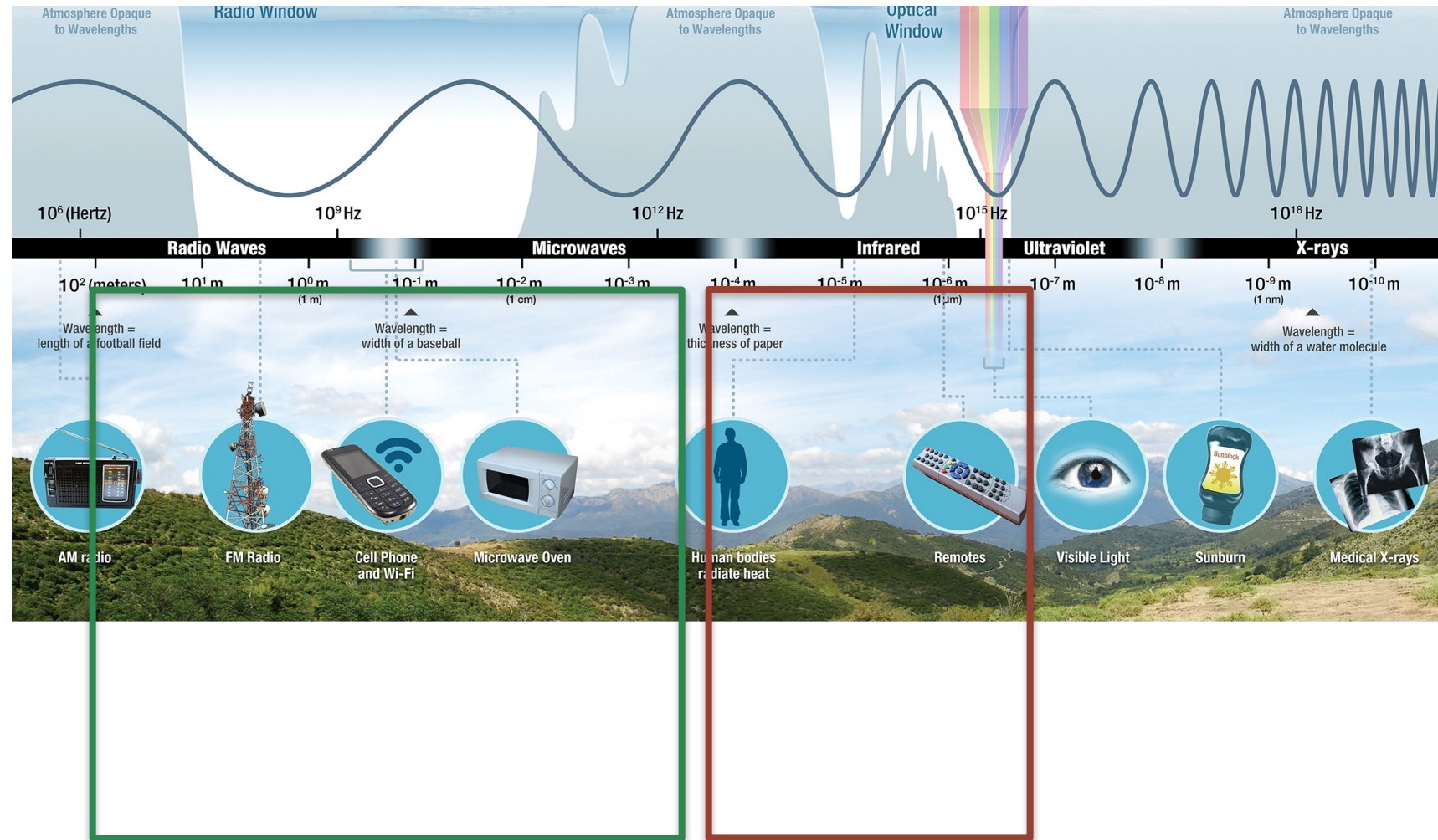


Left: MODIS Aqua satellite image from October 23, 2011, showing areas of elevated chlorophyll a (in red and orange)



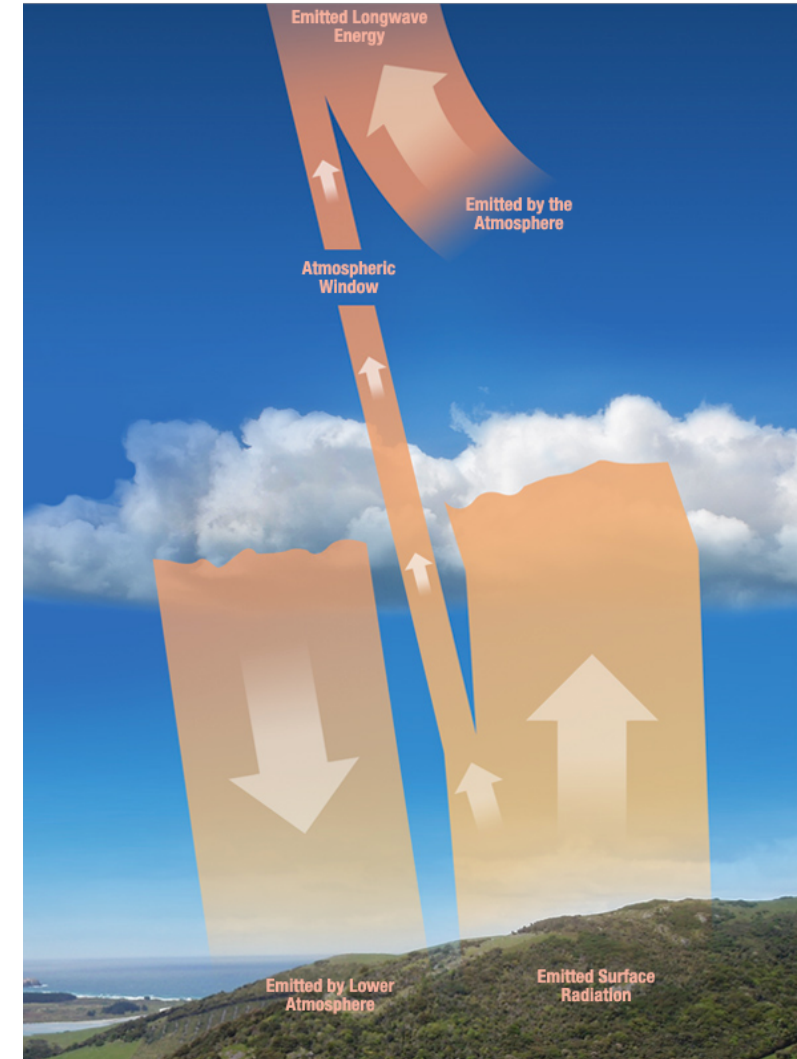
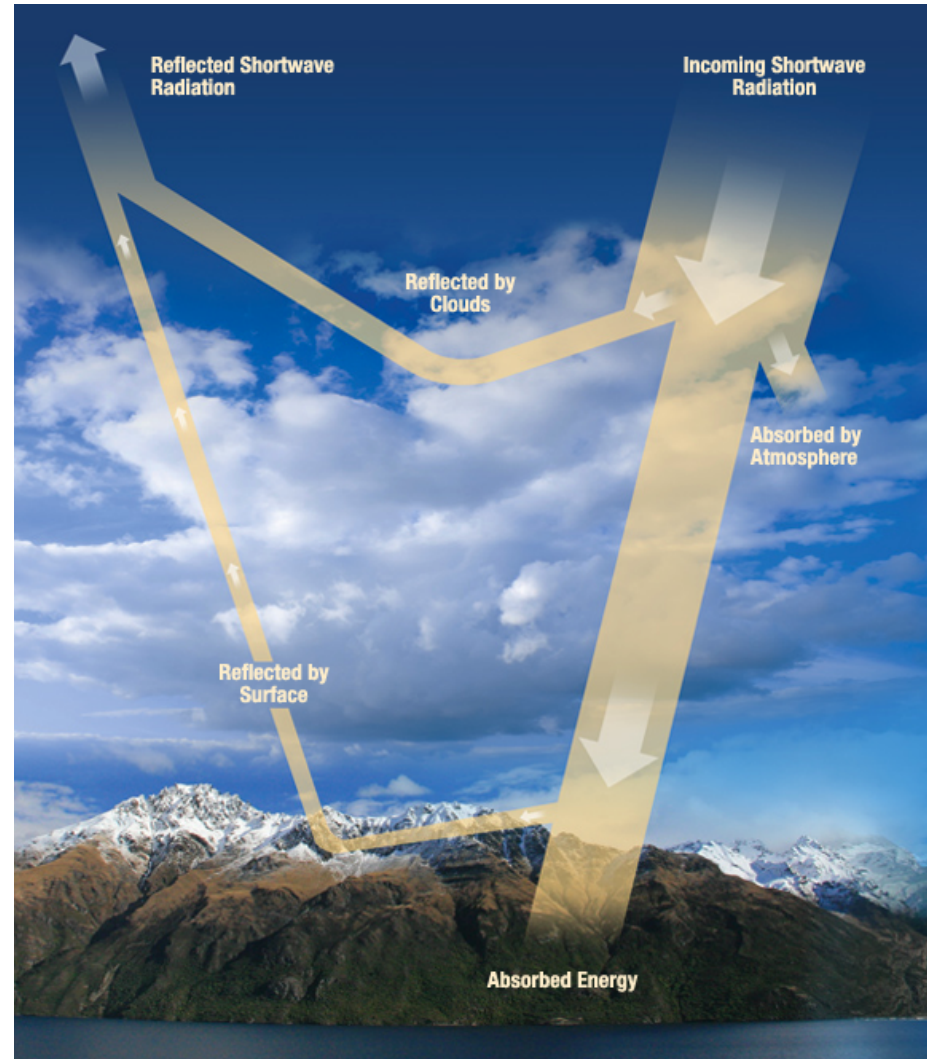
Remote Sensing of Water Quality

- Satellites carry instruments and sensors to measure:
 - reflected solar radiation
 - emitted infrared and microwave radiation

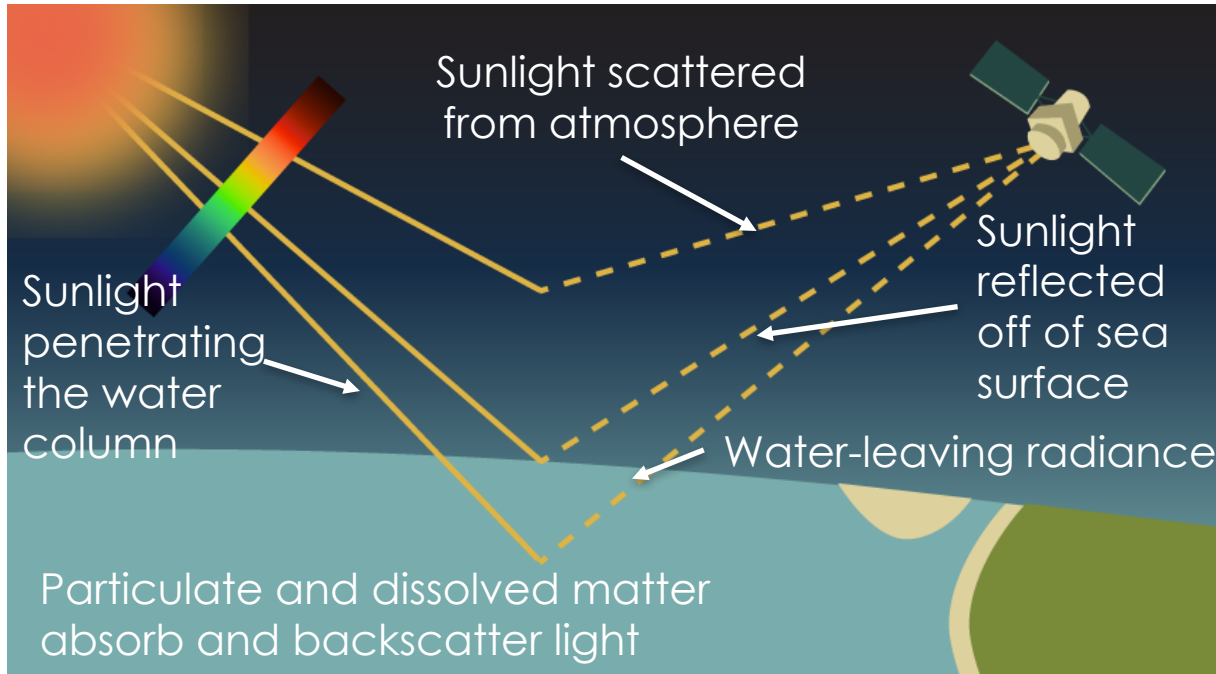


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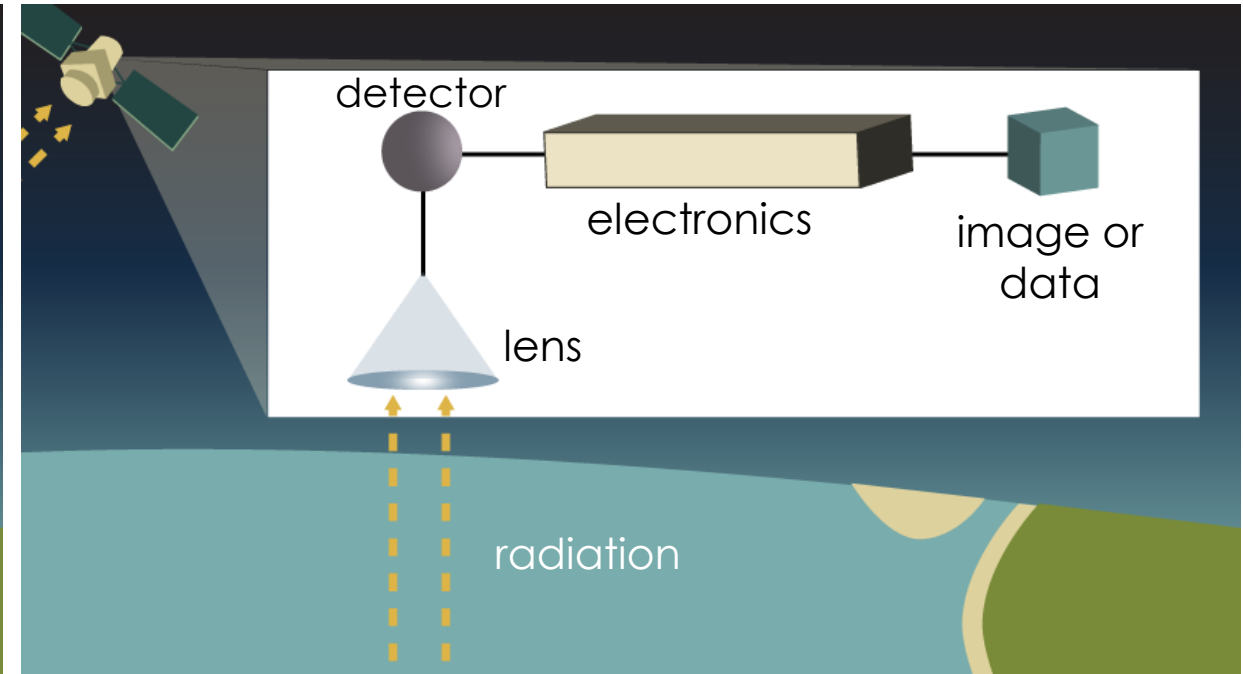


Remote Sensing of Water Quality



Reflected solar radiation measured by satellite sensors is used to derive optically-active water constituents:

- Turbidity and Suspended Sediments
- Colored Dissolved Organic Matter (CDOM)
- Chlorophyll-a (phytoplankton)



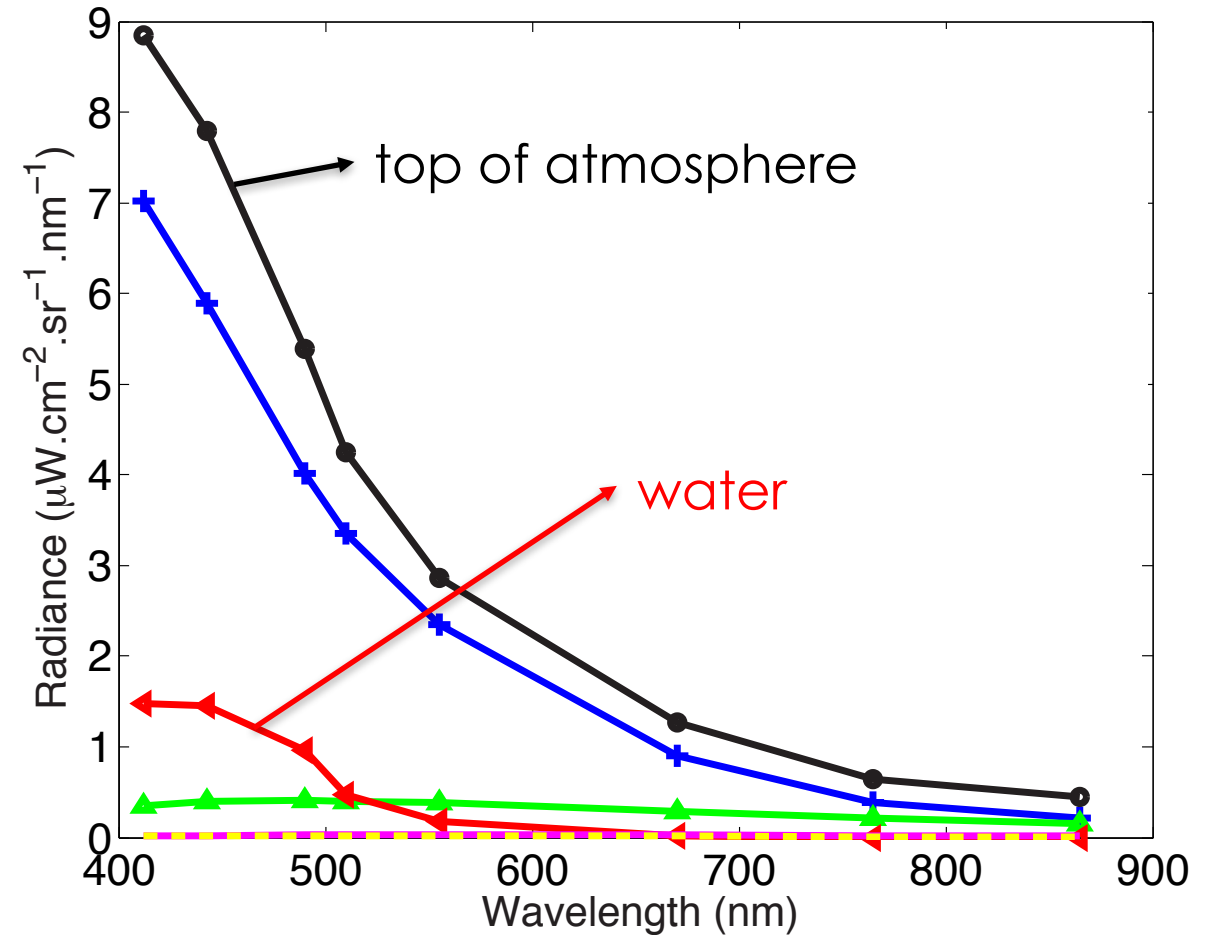
Emitted thermal infrared and microwave radiation measured by satellite sensors is used to derive:

- Surface Temperature
- Salinity



Remote Sensing of Water Quality

- Satellite observations of reflectances have to be corrected for atmospheric effects to derive water quality



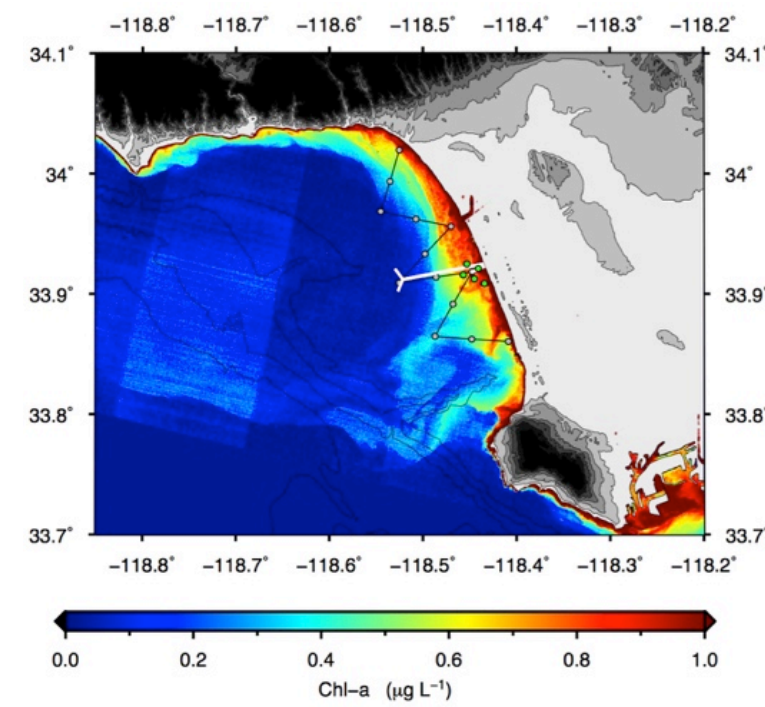
Remote Sensing of Water Bodies

Techniques

Simple image interpretation to derive **qualitative information** about water quality



Use of various types of algorithms combining atmospherically corrected satellite images and in situ measurements to derive **quantitative information** about water quality



*In Situ
Observations
Required*



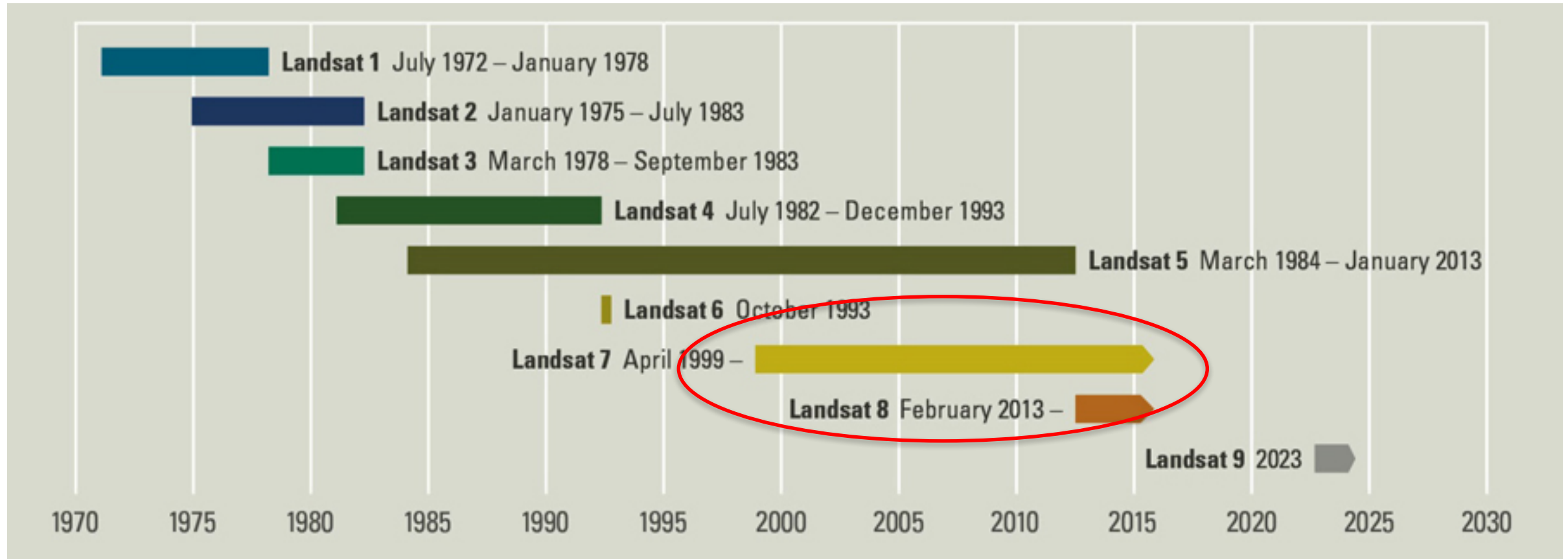
Satellites for WQ Monitoring

- Current Satellite Missions:
 - Landsat 7 & Landsat 8
 - Terra
 - Aqua
 - Suomi National Polar Partnership (SNPP)
 - Sentinel-2 and Sentinel-3



Landsat Satellites and Sensors

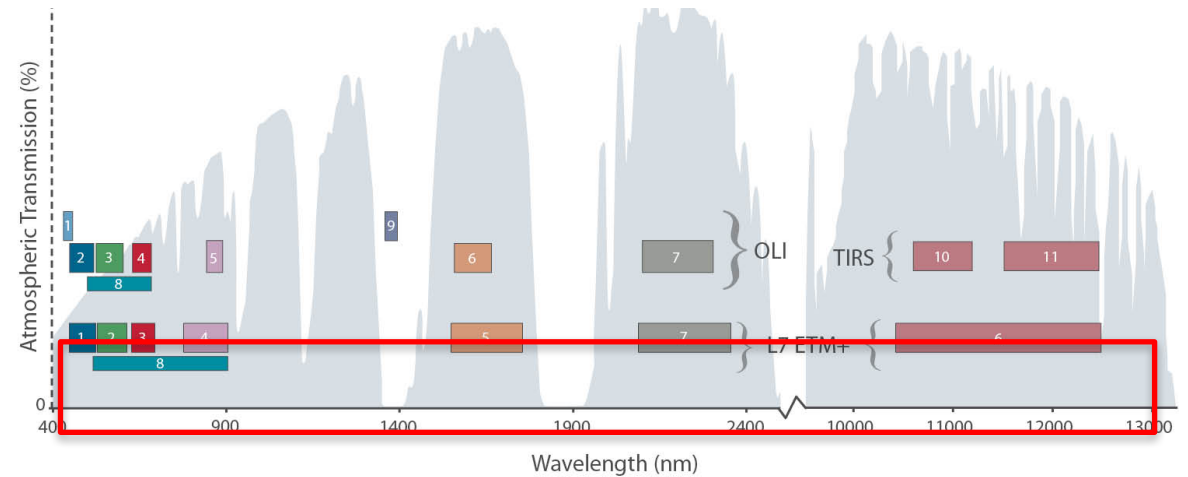
<http://landsat.gsfc.nasa.gov/>



Enhanced Thematic Mapper (ETM+)

<http://landsat.gsfc.nasa.gov/landsat-7/>

- Onboard **Landsat 7**
- Polar orbiting satellite
- Spatial Coverage and Resolution:
 - Global, Swath: 185 km
 - Spatial Resolution:
 - 15 m, 30 m, 60 m
- Temporal Coverage and Resolution:
 - April 15, 1999 – present
 - 16-day revisit time



Spectral Bands: 8

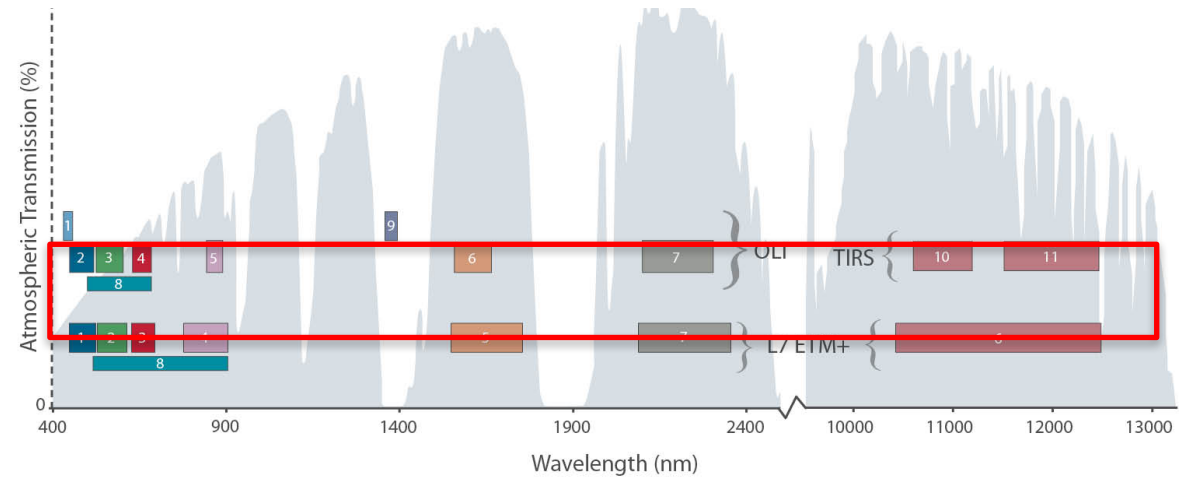
- Major Bands: blue-green, green, red, thermal IR, panchromatic
 - Bands 1-5, 7: 30 m
 - Band 6: 60 m
 - Band 8: 15 m



Operational Land Imager (OLI)

<http://landsat.gsfc.nasa.gov/landsat-8/>

- Onboard **Landsat 8**
- Polar orbiting satellite
- Spatial Coverage and Resolution
 - Global, Swath: 185 km
 - Spatial Resolution: 15 m, 30 m
- Temporal Coverage and Resolution:
 - Feb 11, 2013 – present
 - 16-day revisit time

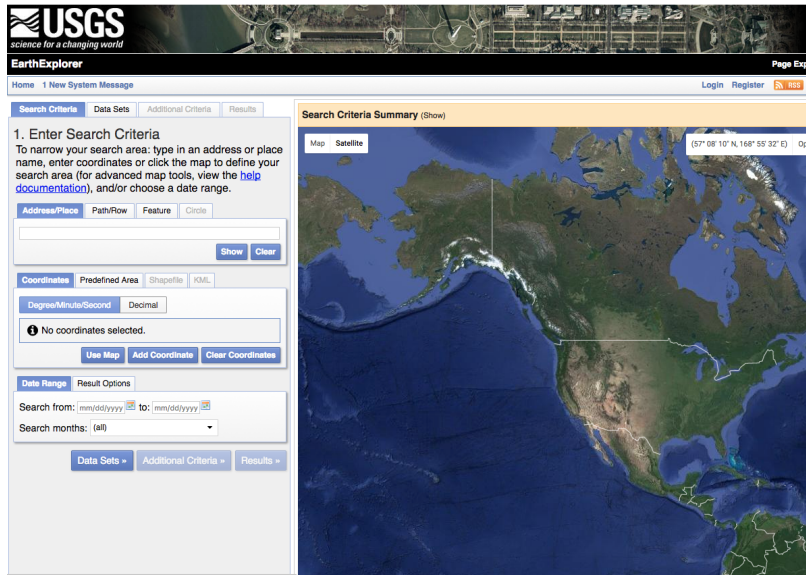


Spectral Bands: 9

- Major Bands: blue, blue-green, red, near IR, shortwave, panchromatic
 - Bands 1-7, 9: 30 m
 - Band 8: 15 m

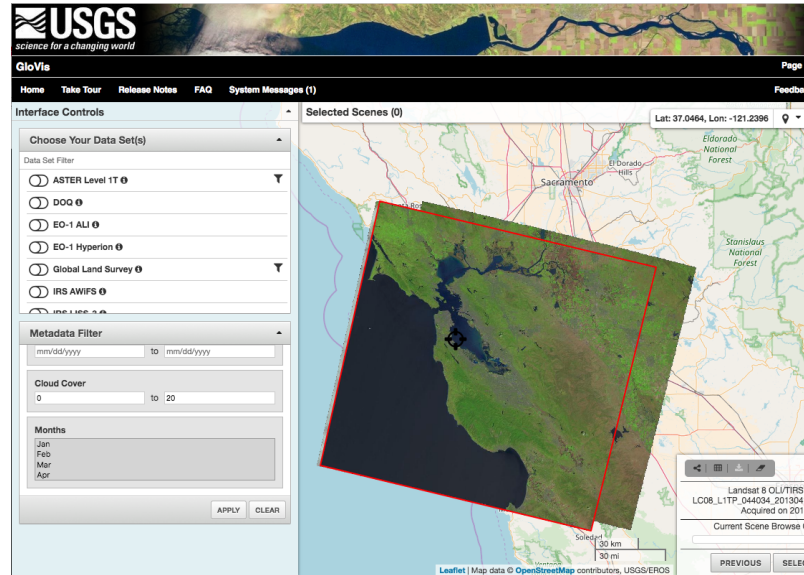


Get Landsat Images and Band Reflectance Data



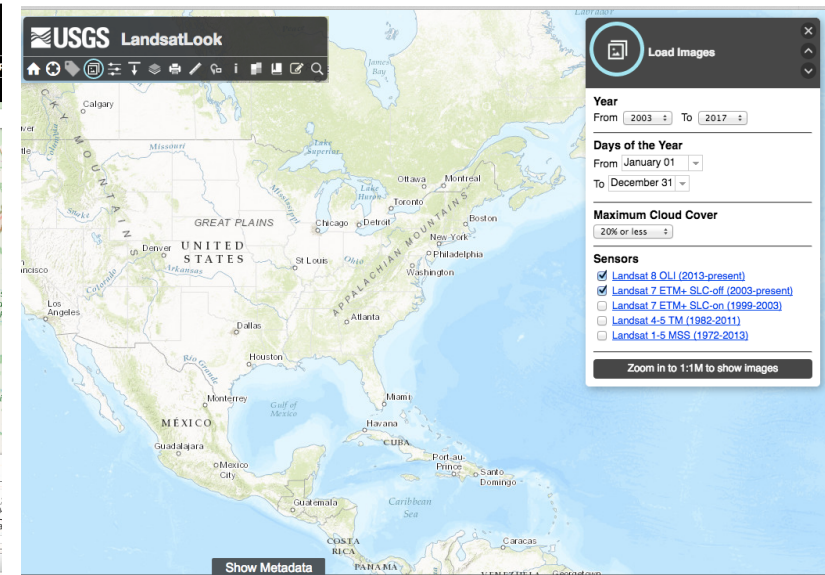
Earth Explorer:

<http://earthexplorer.usgs.gov/>



GloVis

<http://glovis.usgs.gov/>



Landsat Look Viewer:

<http://landsatlook.usgs.gov/>



Terra and Aqua Satellites and Sensors

Terra

<http://terra.nasa.gov>

- Polar orbit, 10:30 a.m. equator crossing time
- Global Coverage
- December 18, 1999 – Present
- 1-2 observations per day
- Sensors:
 - ASTER, CERES, MISR, MODIS, MOPITT

Aqua

<http://aqua.nasa.gov/>

- Polar orbit, 1:30 p.m. equator crossing time
- Global Coverage
- May 4, 2002 – Present
- 1-2 observations per day
- Sensors:
 - AIRS, AMSU, CERES, MODIS, AMSR-E



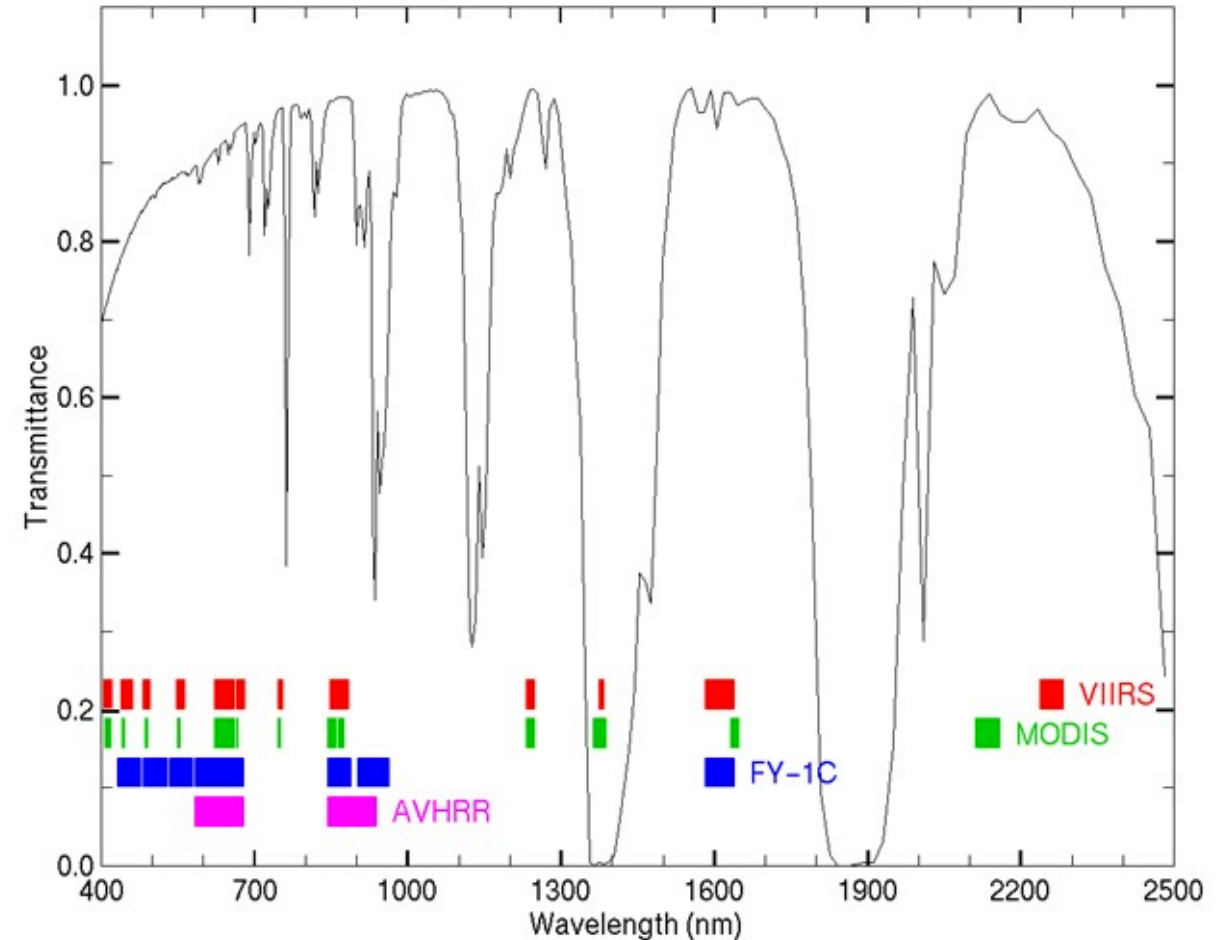
MODerate Resolution Imaging Spectroradiometer (MODIS)

<http://modis.gsfc.nasa.gov/>

- Onboard **Terra** and **Aqua**
- Designed for land, atmosphere, ocean, and cryosphere observations
- Spatial Coverage and Resolution:
 - Global, swath: 2,330 km
 - Spatial resolution varies: 250 m, 500 m, 1 km
- Temporal Coverage and Resolution:
 - 2000 – present, 1–2 times per day

Spectral Bands: 36

- Reflection and Emission Bands (Major Bands: red, blue, IR, NIR, MIR)
- Bands 1-2: 250 m; Bands 3-7: 500 m; Bands 8-36: 1,000 m



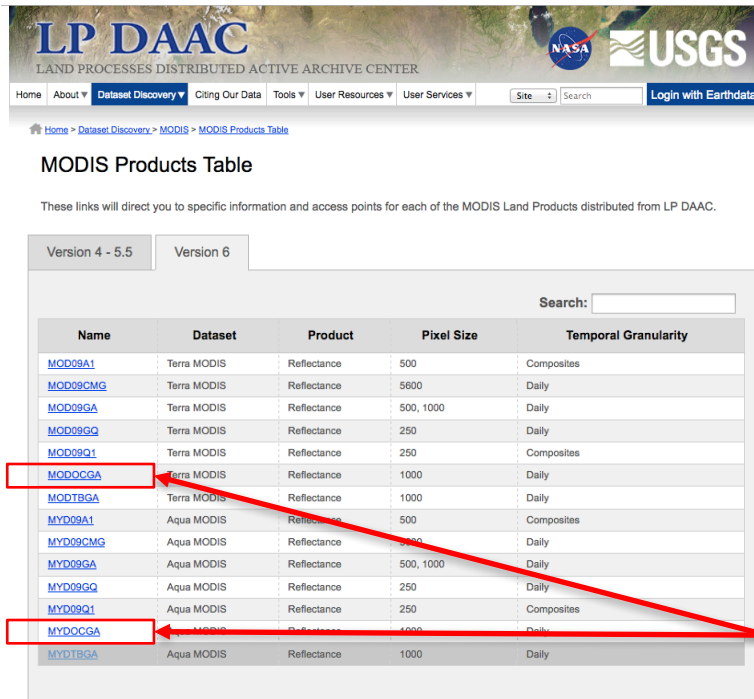
Credit: Li, J. (2001 Dec 18) *Atmospheric Temperature, Moisture, Ozone, and Motion-Infrared (MOD-07)*. CIMSS



Get MODIS Band Reflectance Data

Land Processing Distributed Active Archive
Center

http://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/

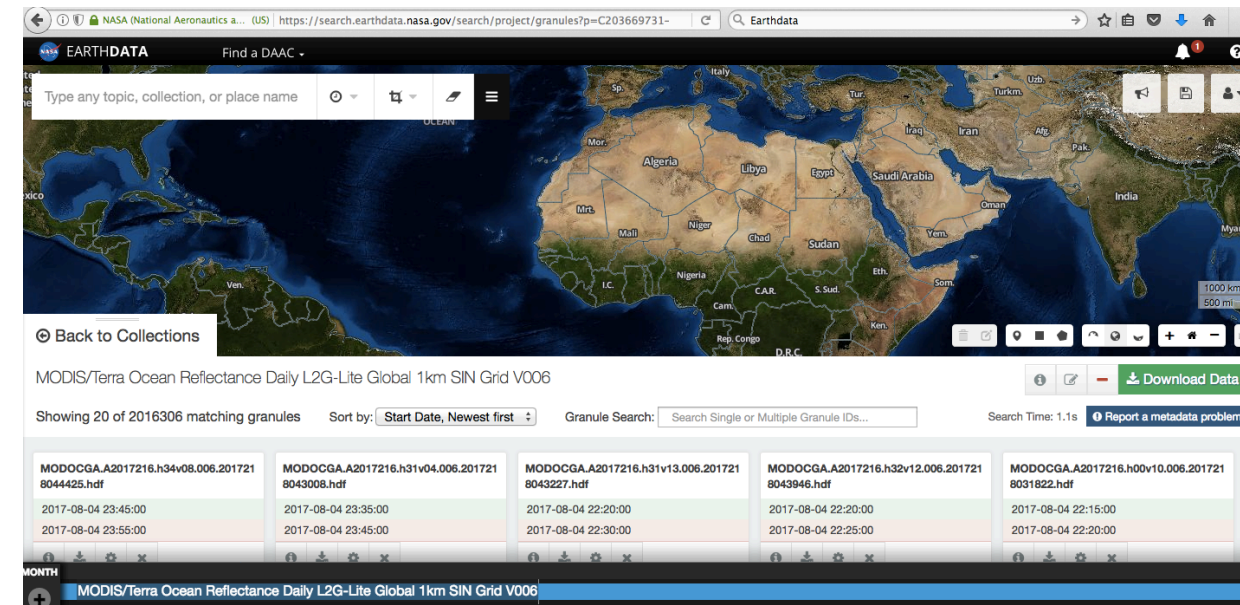


The screenshot shows the LP DAAC website with the 'MODIS Products Table' section. A red box highlights the 'MODOCGA' and 'MYDOCGA' rows in the table. A red arrow points from the 'MODOCGA' row to the 'MODIS/Terra Ocean Reflectance Daily L2G-Lite Global 1km SIN Grid V006' product name in the adjacent screenshot.

Name	Dataset	Product	Pixel Size	Temporal Granularity
MOD09A1	Terra MODIS	Reflectance	500	Composites
MOD09CMG	Terra MODIS	Reflectance	5600	Daily
MOD09GA	Terra MODIS	Reflectance	500, 1000	Daily
MOD09GQ	Terra MODIS	Reflectance	250	Daily
MOD09Q1	Terra MODIS	Reflectance	250	Composites
MODOCGA	Terra MODIS	Reflectance	1000	Daily
MODT8GA	Terra MODIS	Reflectance	1000	Daily
MYD09A1	Aqua MODIS	Reflectance	500	Composites
MYD09CMG	Aqua MODIS	Reflectance	5600	Daily
MYD09GA	Aqua MODIS	Reflectance	500, 1000	Daily
MYD09GQ	Aqua MODIS	Reflectance	250	Daily
MYD09Q1	Aqua MODIS	Reflectance	250	Composites
MYDOCGA	Aqua MODIS	Reflectance	1000	Daily
MYDT8GA	Aqua MODIS	Reflectance	1000	Daily

NASA Earthdata

<http://earthdata.nasa.gov/>



The screenshot shows the NASA Earthdata search results for the product 'MODIS/Terra Ocean Reflectance Daily L2G-Lite Global 1km SIN Grid V006'. It displays a map of the world with a focus on the ocean, and a table of granules with their respective dates and times. A red arrow from the 'MODOCGA' row in the previous screenshot points to this search result.

MODIS/Terra Ocean Reflectance Daily L2G-Lite Global 1km SIN Grid V006

Showing 20 of 2016306 matching granules Sort by: Start Date, Newest first Granule Search: Search Single or Multiple Granule IDs... Search Time: 1.1s Report a metadata problem

Granule ID	Start Date	End Date
MODOCGA.A2017216.h34v08.006.2017218044425.hdf	2017-08-04 23:45:00	2017-08-04 23:55:00
MODOCGA.A2017216.h31v04.006.20172180433008.hdf	2017-08-04 23:35:00	2017-08-04 23:45:00
MODOCGA.A2017216.h31v13.006.2017218043227.hdf	2017-08-04 22:20:00	2017-08-04 22:30:00
MODOCGA.A2017216.h32v12.006.2017218043946.hdf	2017-08-04 22:20:00	2017-08-04 22:25:00
MODOCGA.A2017216.h00v10.006.2017218031822.hdf	2017-08-04 22:15:00	2017-08-04 22:20:00

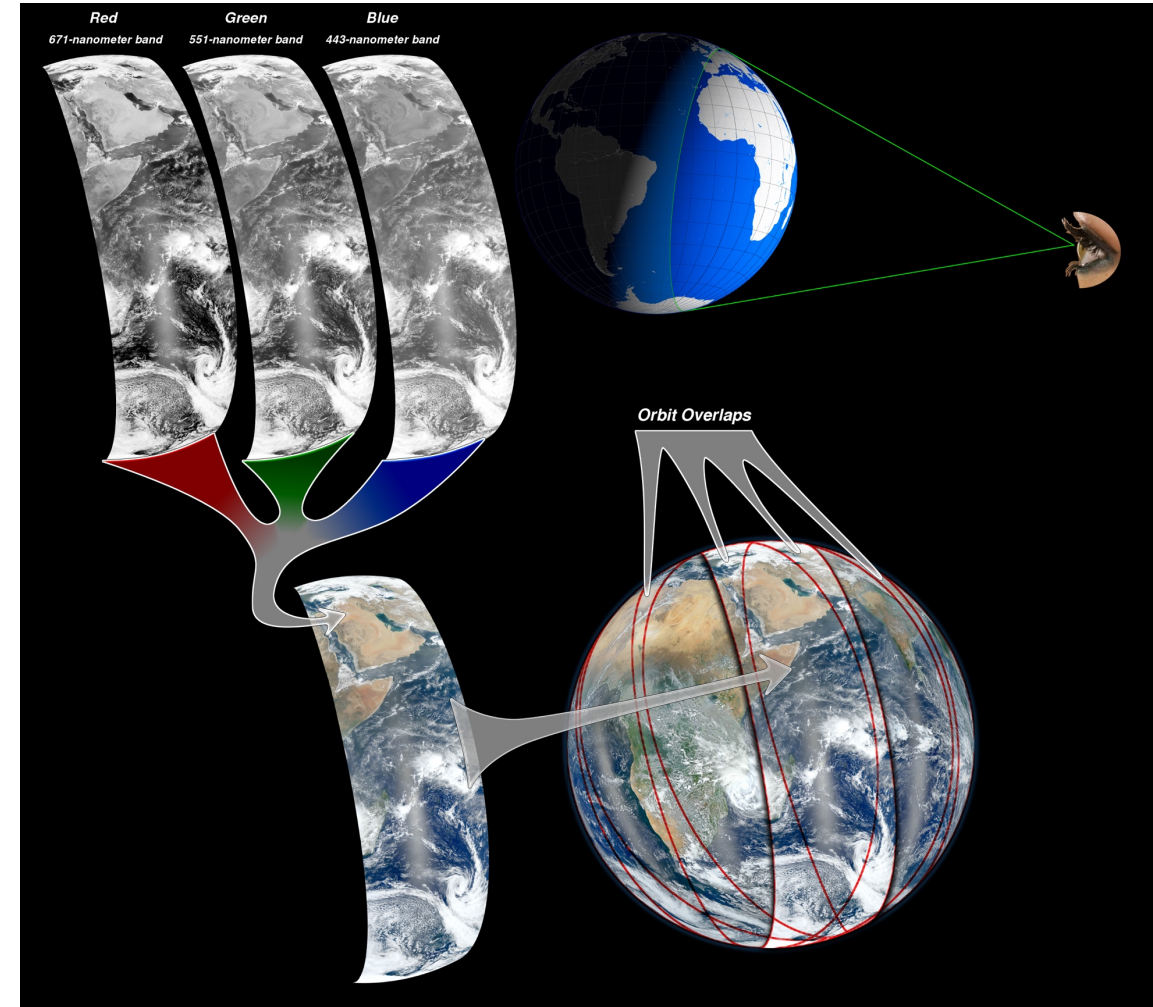
MODIS Band Reflectance for Oceans, Bands 8-16
Product Name: MODOCGA (Terra), MYDOCGA (Aqua)



Suomi National Polar Partnership (SNPP)

http://nasa.gov/mission_pages/NPP/

- Polar orbit, 1:30 p.m. equator crossing time
- Global coverage
- November 21, 2011 – present
- Sensors:
 - VIIRS, ATMS, CrIS, OMPS, CERCEs



Visible Infrared Imaging Radiometer Suite (VIIRS)

<http://jointmission.gsfc.nasa.gov/viirs.html>

- Onboard **Suomi NPP**
- Polar orbiting satellite
- Functionality similar to MODIS
- Spatial Coverage and Resolution:
 - Global, Swath Width: 3,040 km
 - Spatial Resolution: 375 – 750 m
- Temporal Coverage and Resolution:
 - Oct 2011 – present
 - 1-2 times per day

True Color Image, Algae in the Caspian Sea

May 18, 2014

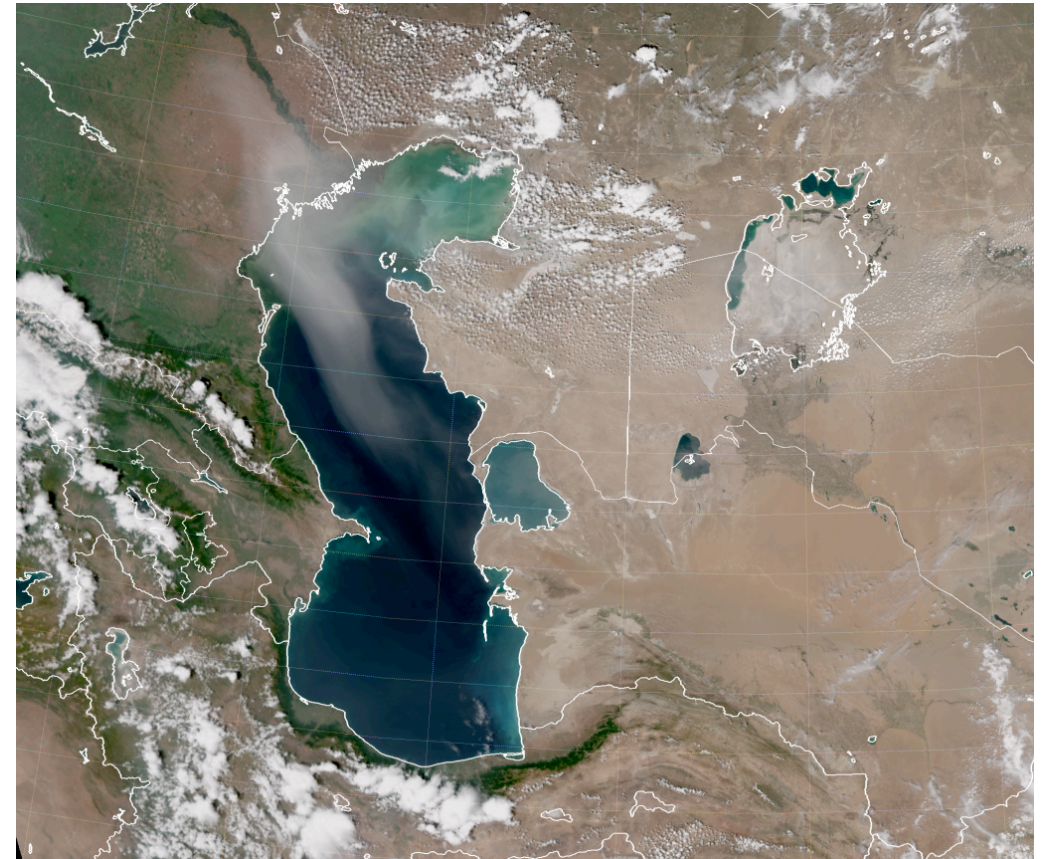
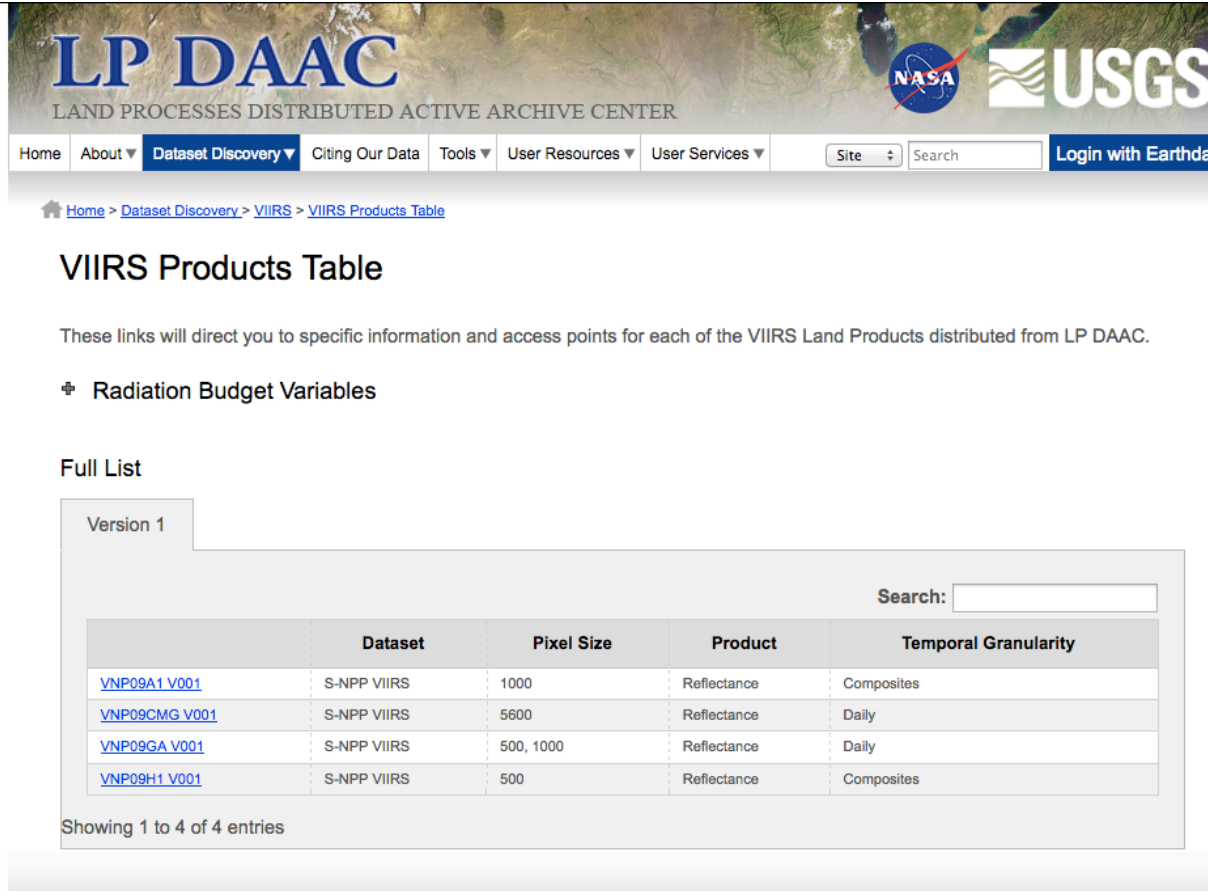


Image Credit: [VIIRS Imagery and Visualization Team Blog](#) VIIRS



Get VIIRS Band Reflectance Data



The screenshot shows the LP DAAC (Land Processes Distributed Active Archive Center) website. The header includes the LP DAAC logo, NASA and USGS logos, and a navigation menu with links like Home, About, Dataset Discovery, Citing Our Data, Tools, User Resources, and User Services. Below the header, there's a breadcrumb trail: Home > Dataset Discovery > VIIRS > VIIRS Products Table. The main heading is "VIIRS Products Table". A subtext states: "These links will direct you to specific information and access points for each of the VIIRS Land Products distributed from LP DAAC." There's a section for "Radiation Budget Variables" with a plus icon. Below that, a "Full List" section shows a table of products. The table has columns for Dataset, Pixel Size, Product, and Temporal Granularity. It lists four products: VNP09A1 V001, VNP09CMG V001, VNP09GA V001, and VNP09H1 V001. A search bar is located above the table. At the bottom, it says "Showing 1 to 4 of 4 entries".

LP DAAC
LAND PROCESSES DISTRIBUTED ACTIVE ARCHIVE CENTER

Home About Dataset Discovery Citing Our Data Tools User Resources User Services Site Search Login with Earthdata

Home > Dataset Discovery > VIIRS > VIIRS Products Table

VIIRS Products Table

These links will direct you to specific information and access points for each of the VIIRS Land Products distributed from LP DAAC.

✚ Radiation Budget Variables

Full List

Version 1

Search:

	Dataset	Pixel Size	Product	Temporal Granularity
VNP09A1 V001	S-NPP VIIRS	1000	Reflectance	Composites
VNP09CMG V001	S-NPP VIIRS	5600	Reflectance	Daily
VNP09GA V001	S-NPP VIIRS	500, 1000	Reflectance	Daily
VNP09H1 V001	S-NPP VIIRS	500	Reflectance	Composites

Showing 1 to 4 of 4 entries

Land Process Distributed Active Archive Center

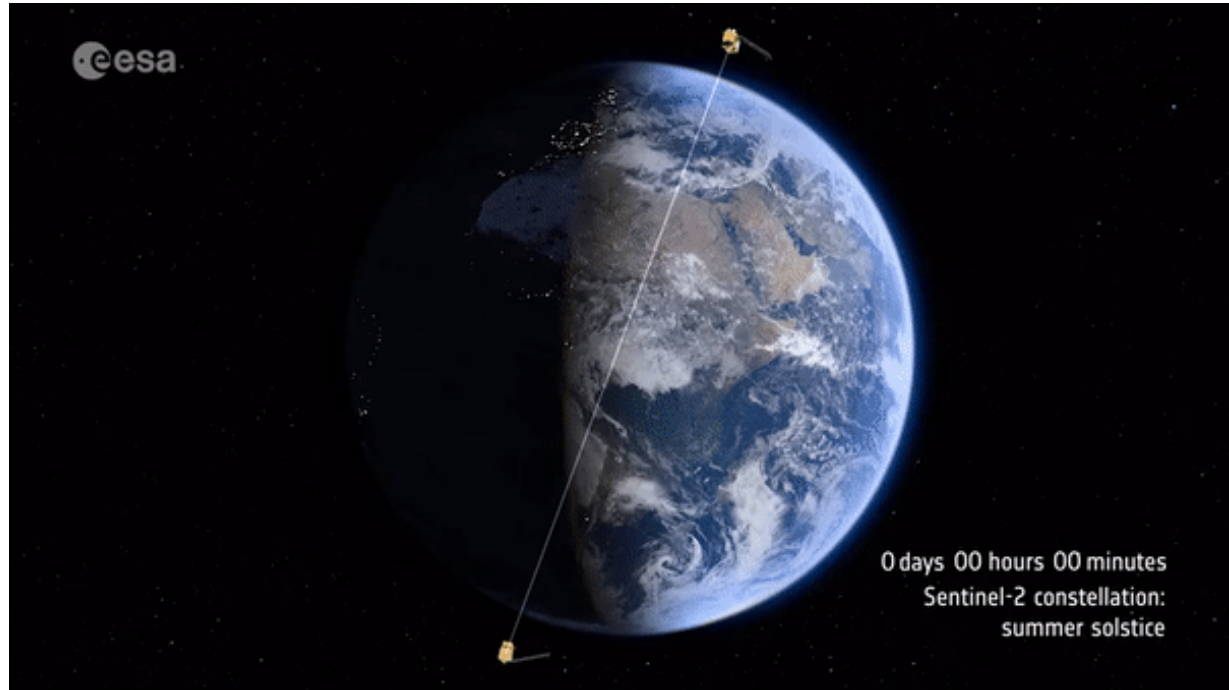
- https://lpdaac.usgs.gov/dataset_discovery/viirs/viirs_products_table
- Product Name: VNP09GA_V001



Sentinel-2A and Sentinel-2B

http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-2/

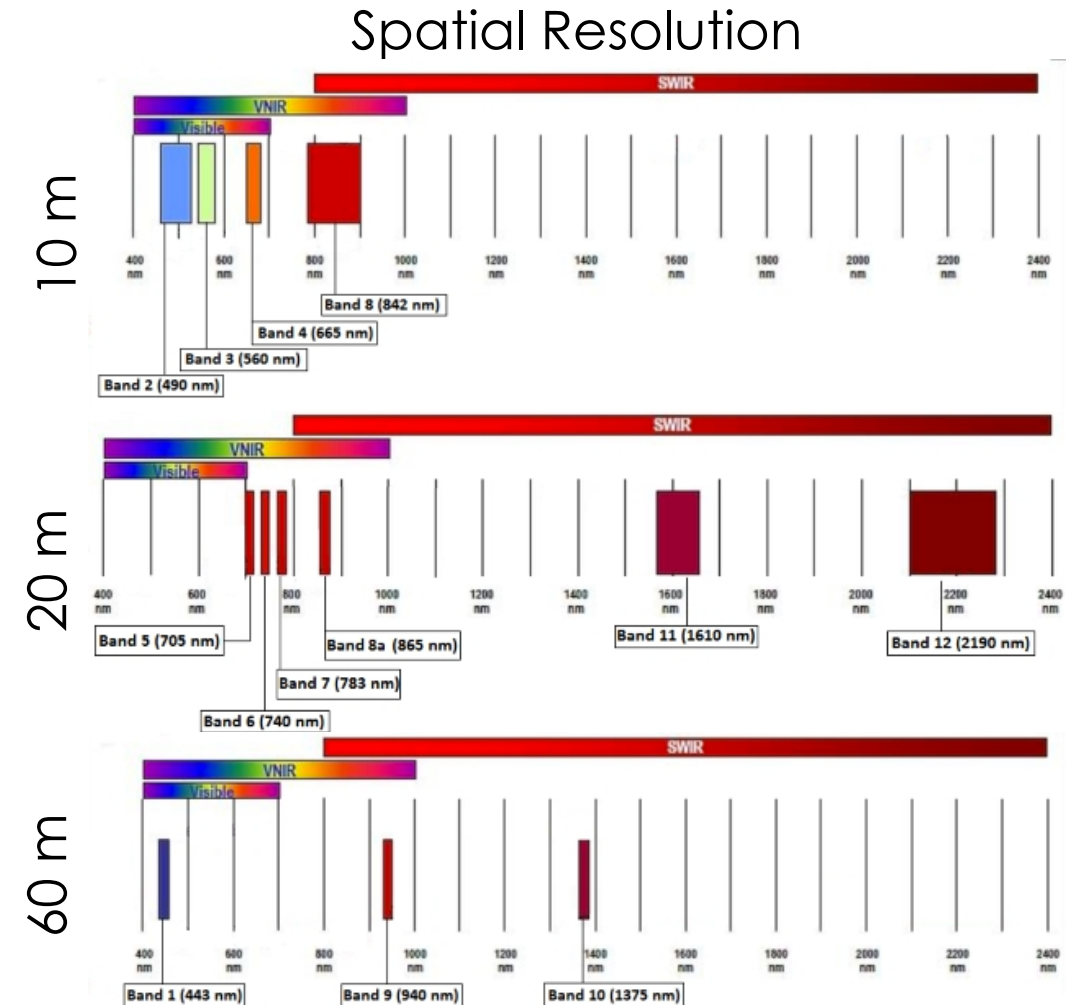
- Launched by **ESA**
- Two satellites, 180° apart, both in polar orbit
- Global coverage
- Temporal Coverage:
 - Sentinel-2A: June 23, 2015 – present
 - Sentinel-2B: March 7, 2017 – present
- 5 day revisit time
- Sensors
 - Multispectral Imager (MSI)



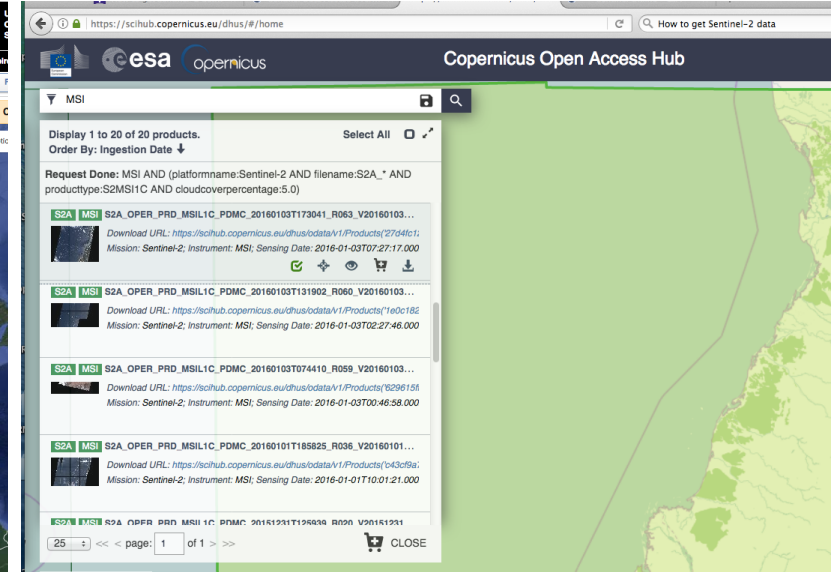
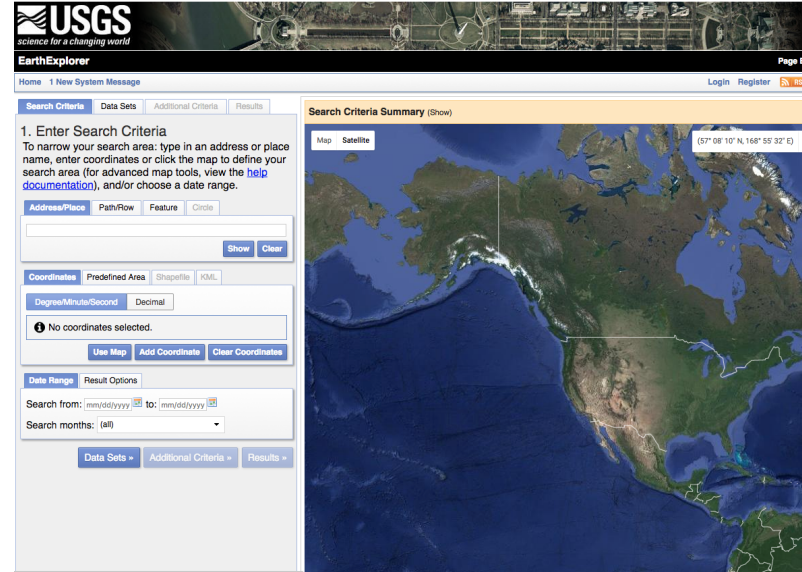
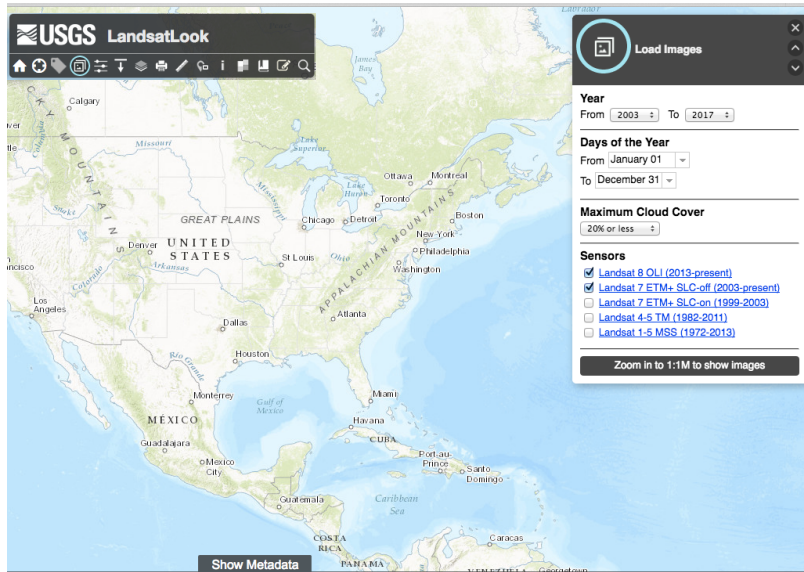
Multispectral Imager (MSI)

<https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi>

- Onboard **Sentinel-2**
- Land and ocean surface observations
- Spatial Coverage and Resolution:
 - Global, swath: 290 km
 - Spatial resolution varies: 10 m, 20 m, 60 m
- Temporal Coverage and Resolution:
 - June 2015 & March 2017 – present
 - 5 day revisit time
- **Spectral Bands: 13**
 - 4 visible and NIR: 10 m
 - 6 red-edge/shortwave infrared: 20 m
 - 3 atmospheric correction: 60 m



Get MSI Data



Landsat Look Viewer:
<http://landsatlook.usgs.gov/>

Earth Explorer:
<http://earthexplorer.usgs.gov/>

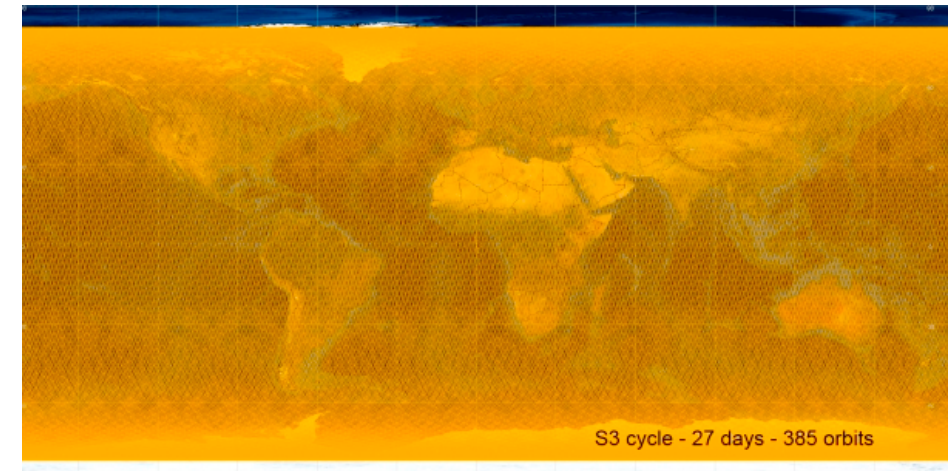
ESA Copernicus Open Hub
<http://sentinel.esa.int/web/sentinel/sentinel-data-access>



Sentinel-3

www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-3/

- Launched by **ESA**
- Will consist of a two satellite system
 - Sentinel-3A: Feb 16, 2016 - present
 - Sentinel-3B: To be launched
- Global coverage
- 27 day revisit time
- Sensors:
 - **OCLI**, SLSTR, SRAL, MWR



Ocean and Land Color Instrument (OLCI)

<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci>

- Onboard **Sentinel-3**
- Based on heritage from ENVISAT satellite Medium Resolution Imaging Spectrometer (MERIS)
- Spatial Coverage and Resolution:
 - Global, swath: 1,270 m
 - Spatial resolution: 300 m, also available at 1.2 km
- Temporal Coverage
 - Feb 2016 – present
 - 27 day revisit time

Spectral Bands: 21

- 4 visible to near-infrared: 300 m

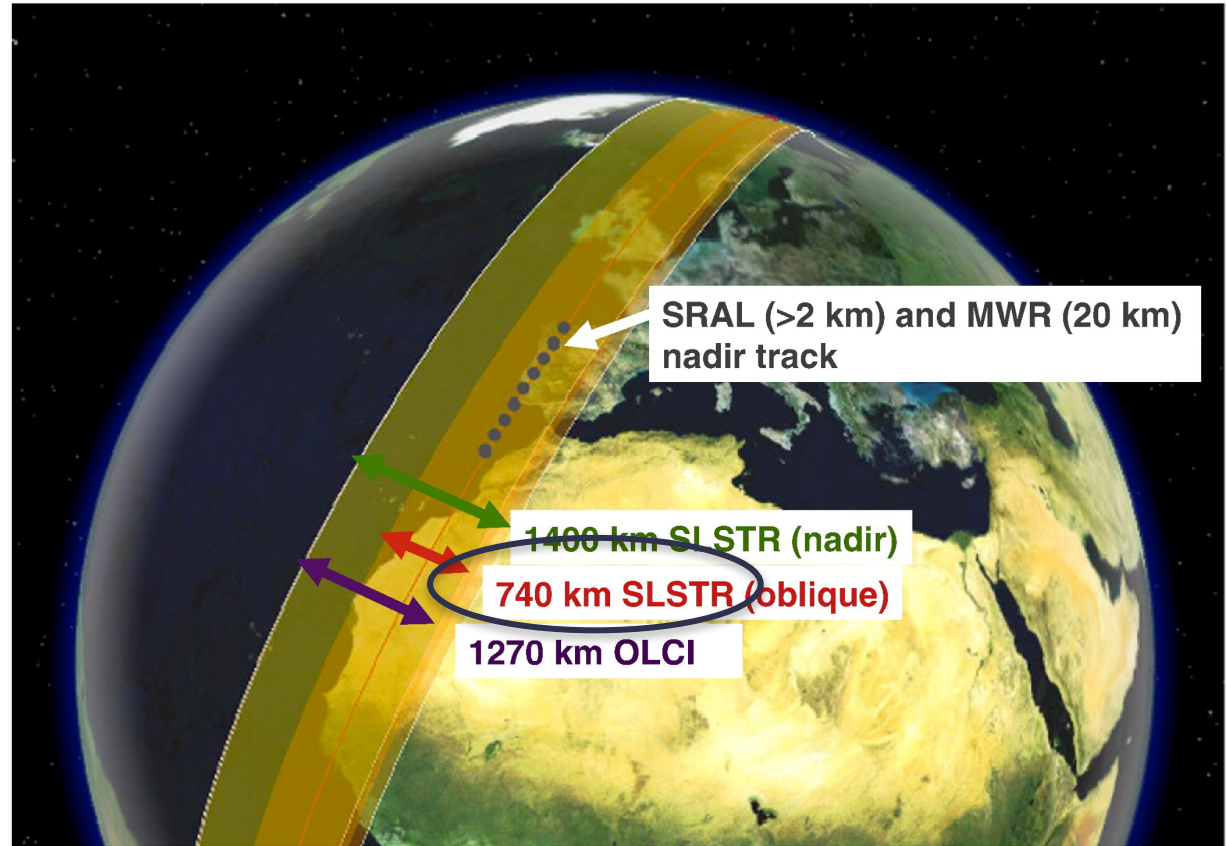
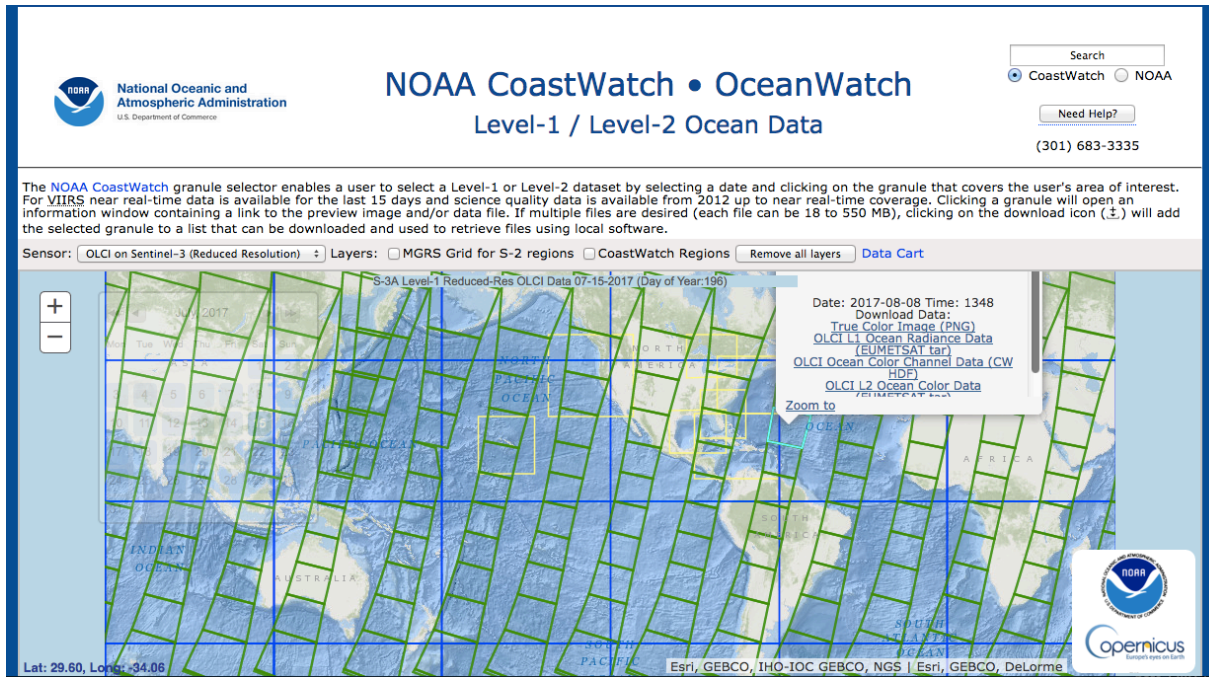


Image Credit: ESA

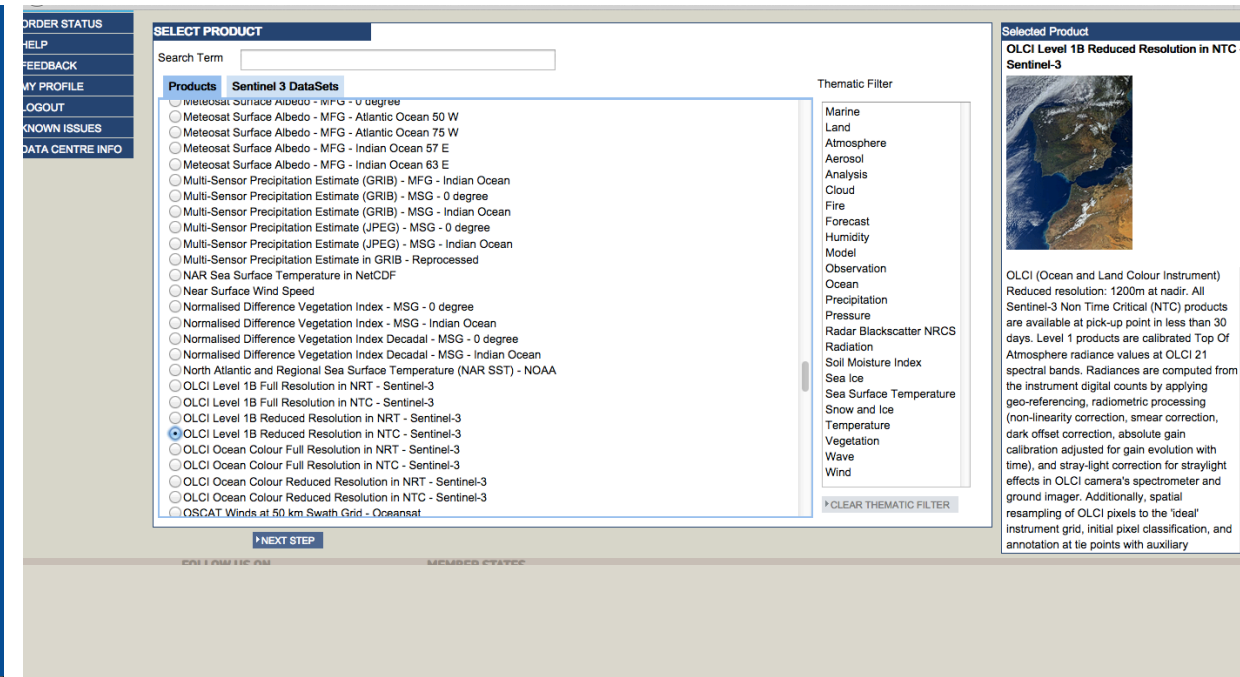


Get OLCI Data



NOAA CoastWatch

https://coastwatch.noaa.gov/cw_html/cw_granule_selector.html?sensor=OLCI



EUMETSAT

<http://archive.eumetsat.int/usc/#sp;;delm=O;noti=1;udsp=OPE;qgov=ALL;seev=0>



Challenges in Monitoring WQ for SDG 6.3.2

- For accurate and quantitative WQ monitoring analysis of spatially and temporally co-located, *in situ* measurements and satellite observations is required
- Feasibility of WQ monitoring in coastal and inland water bodies depends on spatial, temporal, and spectral resolutions of remote sensing observations
- Difficult to separate WQ parameters when sediments, dissolved matter, and Chl-a all are present
- It is not possible to characterize algal types or toxins only from remote sensing observations
- Remote sensing reflectance has to be corrected to account for contributions from atmospheric constituents such as aerosols
- Optical remote sensing observations cannot view the surface in the presence of clouds



Summary of Resources for Monitoring WQ for SDG 6.3.2

- Studies use optical and NIR remote sensing observations for qualitative and quantitative WQ monitoring in lakes, rivers, and coastal regions (see a review in Golizadeh et al., 2016 for techniques and case studies)
 - Landsat
 - Terra/Aqua MODIS
 - SNPP VIIRS
 - Sentinel-2 MSI
 - Sentinel-3 OLCI
- Several web tools use satellite-derived Chl-a and SST to monitor Harmful Algal Blooms
 - Landsat can monitor close to 170, 240 lakes
 - MODIS/OLCI would resolve ~1,862 lakes (Wilson Salls, EPA)

Reference: Gholizadeh, M. H., A. M/ Melesse, L. Reddy, 2016: Spaceborne and airborne sensors in water quality assessment, International J. of Remote Sensing, 37, 3143-3180.






Examples of Monitoring Harmful Algal Boom Indicators
Chlorophyll-a Concentration and Water Surface
Temperature

Ch-a and SST Data from Aqua and Terra MODIS

http://optics.marine.usf.edu/cgi-bin/optics_data?roi=ECARIB¤t=1/

 UNIVERSITY OF
SOUTH FLORIDA

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Marine Science Home | USF St. Pete | Search

College of Marine Science

Optical Oceanography Laboratory

Eastern Caribbean Region & Data Description ? Tips Animate

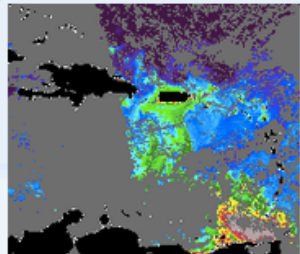
Aug 2017

Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

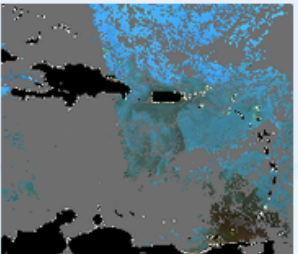
Menu

- Home
- People
- Projects
- Satellite Data Products
- Virtual Buoy Products
- Publications
- Events
- Links
- Contact

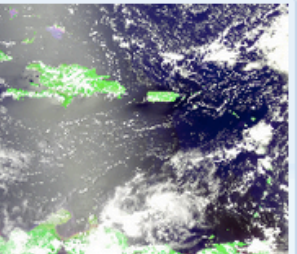
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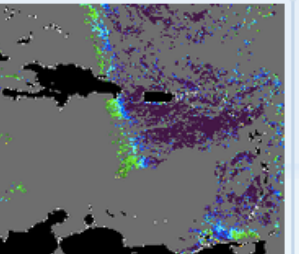
CHL L3D Information
Get Link Here GE



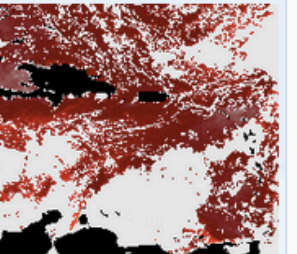
ERGB L3D Information
Get Link Here GE



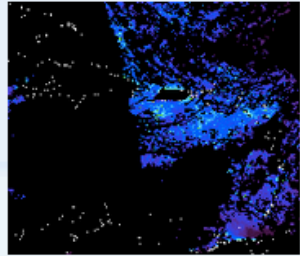
FRGB L3D Information
Get Link Here GE



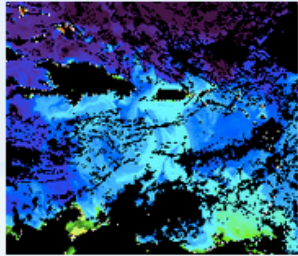
NFLH L3D Information
Get Link Here GE



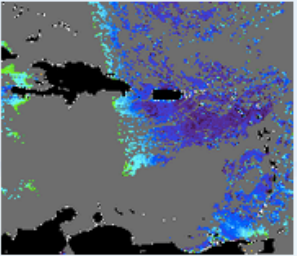
SST L3D Information
Get Link Here GE




AFAI L3D_RRC Information
Get Link Here GE



CI L3D_RRC Information
Get Link Here GE



FLH L3D_RRC Information
Get Link Here GE



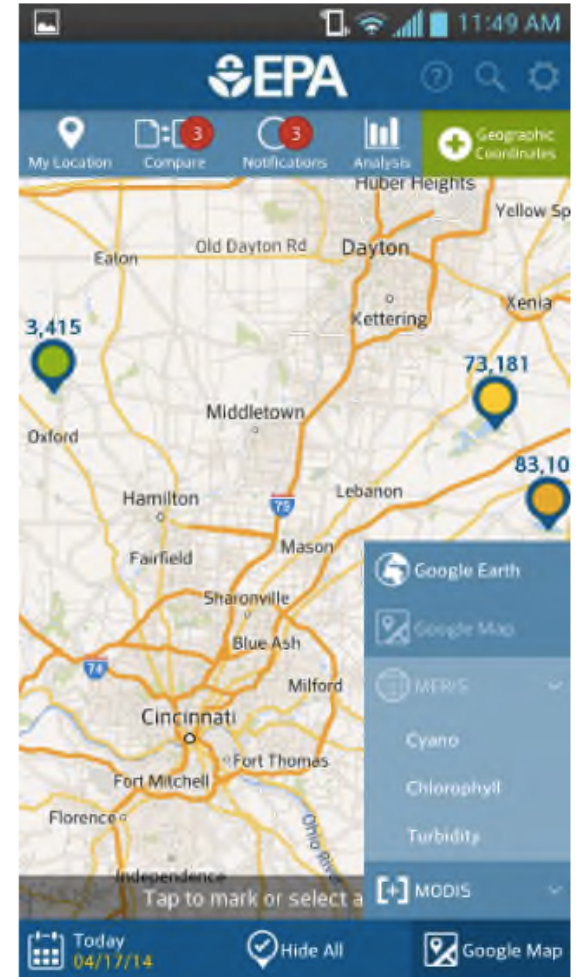
RGB L3D_RRC Information
Get Link Here GE



Cyanobacteria Assessment Network (CyAN)

<https://www.epa.gov/water-research/cyanobacteria-assessment-network-cyan#decision%20support>

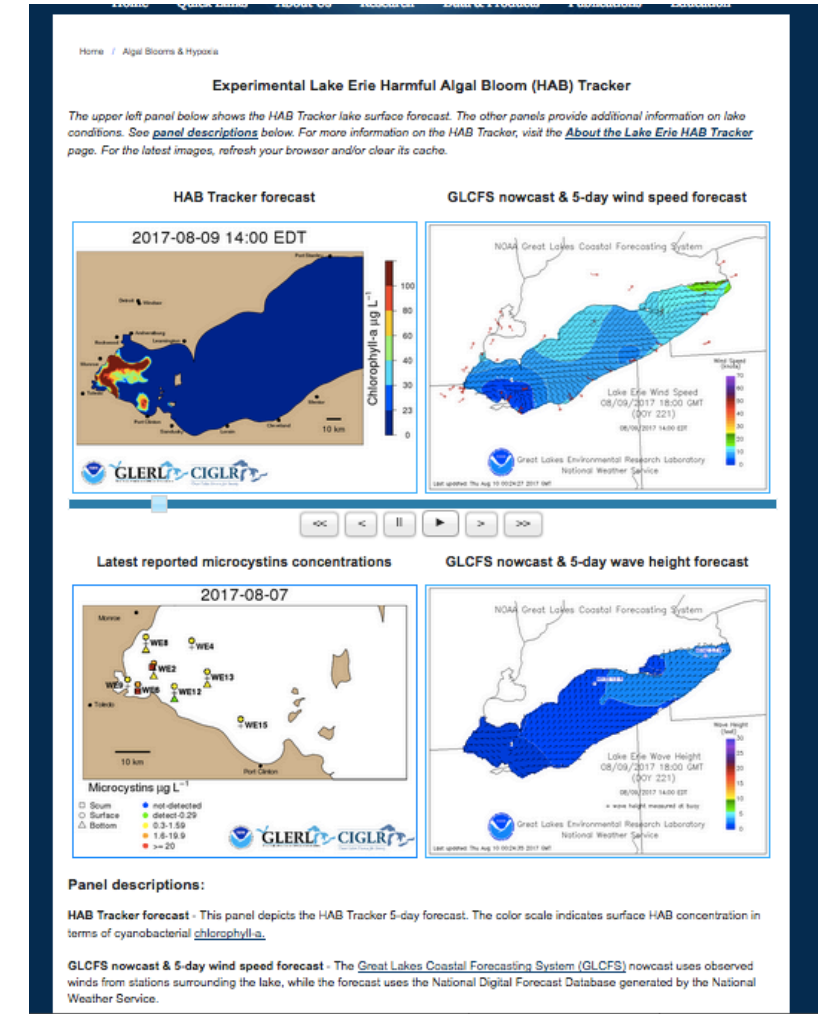
- A collaborative program among EPA, NOAA, NASA, and USGS
- Focused on an early and uniform approach to algal bloom identification using satellite remote sensing from Landsat, Sentinel-2, and Sentinel-3
- Develop a decision support system for stakeholders



Lake Erie HAB Tracker

https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/habTracker.html

- A forecast model based on:
 - MODIS satellite images
 - Weather forecast information
 - Modeled currents in Lake Erie
- Provides:
 - HAB measurements based on in situ water sample collection
 - Near real-time and 5 day HAB forecasts in terms of cyanobacterial chl-a



Lake Erie HAB Tracker

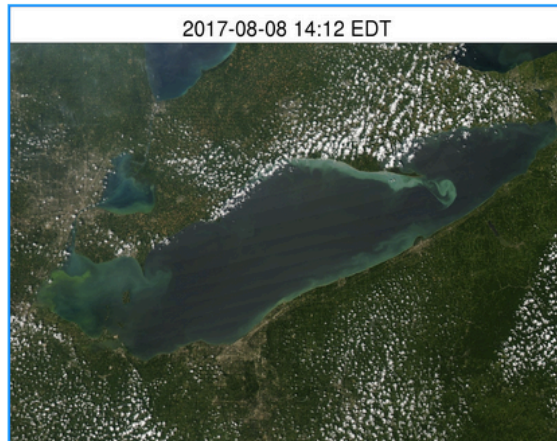
https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/habTracker.html

MODIS-Derived Cyanobacterial Density

Latest satellite-derived data used by the HAB Tracker

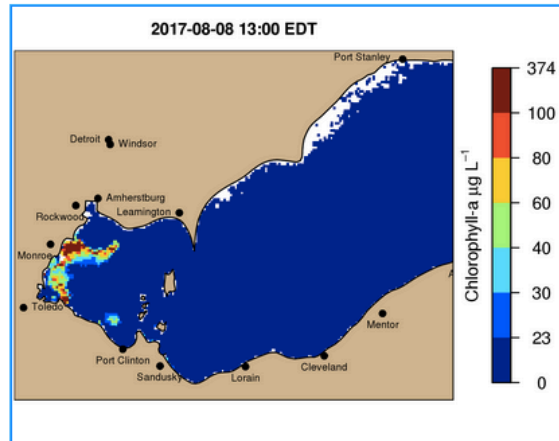
Sensors attached to satellites gather data, which is processed into the cyanobacterial index, an indicator of the abundance, or biomass, of the cyanobacteria associated with HABs. Processed satellite imagery is provided by the [NOAA HAB Operational Forecasting System](#). The cyanobacterial index scale is converted to a cyanobacterial chlorophyll scale for use in the HAB Tracker, a similar indicator of cyanobacterial abundance.

True-color satellite image of Lake Erie



Latest usable (relatively cloud-free) satellite image of Lake Erie. For additional satellite imagery of Lake Erie, visit the [NOAA Great Lakes CoastWatch](#) webpage.

HABs extent analysis



Latest HAB extent analysis from valid satellite imagery above used to update the bloom location in the model.



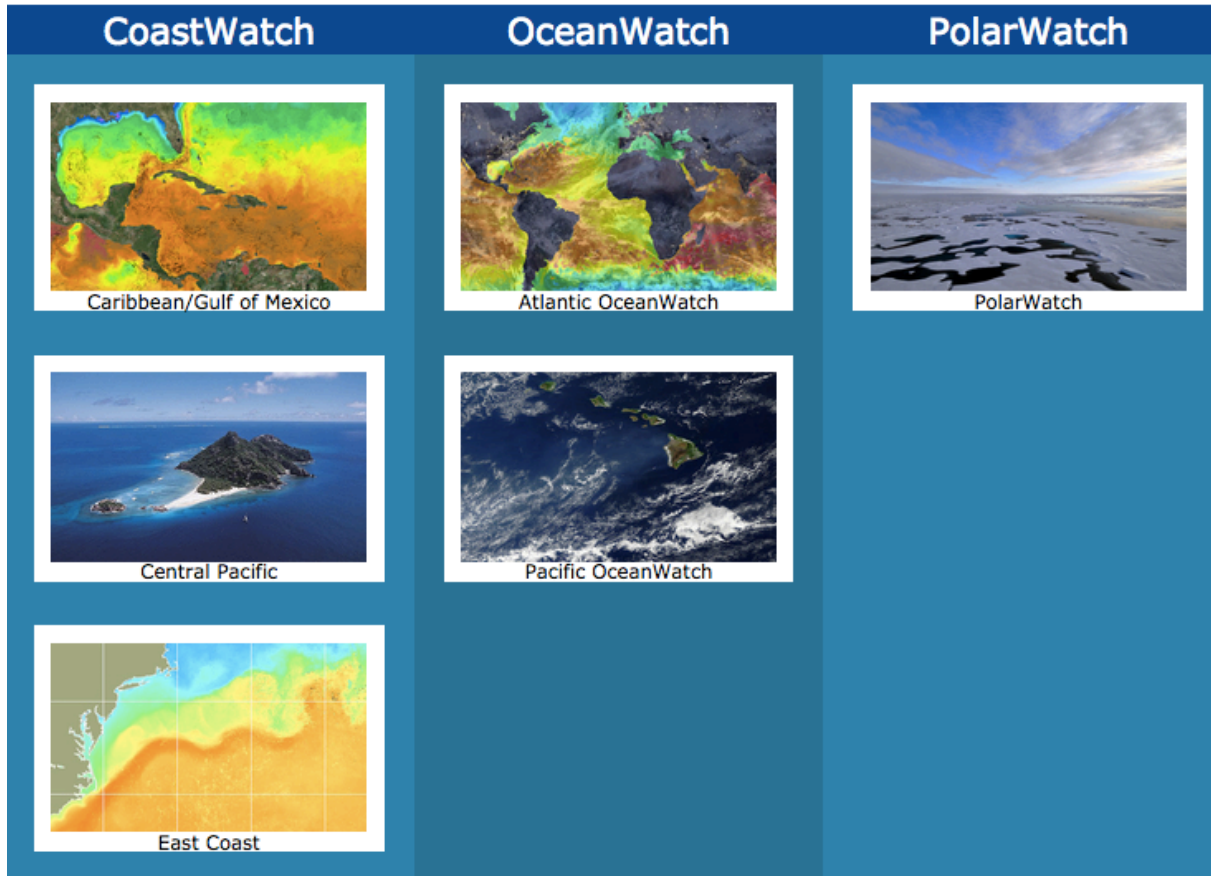
Photo Credit: NOAA GLERL



NOAA Coast Watch

https://coastwatch.noaa.gov/cw_html/index.html

- Information provided for multiple coastal areas



- Satellite products used
 - True-color Imagery
 - Ocean Color – Radiances and Chlorophyll-a Concentration
 - Sea Surface Temperatures
 - Sea Surface Height
 - Sea Surface Salinity
 - Sea Surface Winds



NOAA Coast Watch

<https://coastwatch.noaa.gov/cw.html/OceanColor.html>

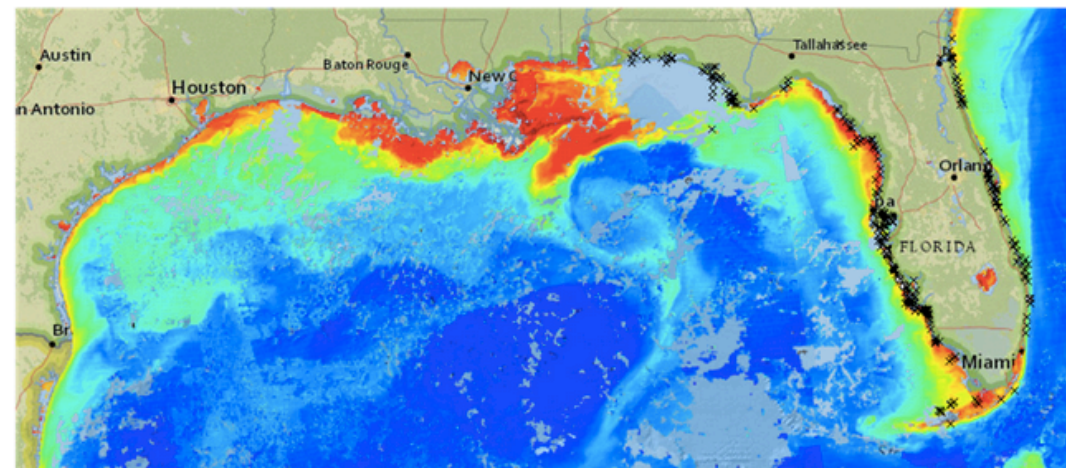
- Satellite-based HAB monitoring
- Near real-time remote sensing data used from:
 - MODIS Aqua
 - VIIRS S-NPP
 - OLCI Sentinel-3

▼ Harmful Algal Bloom Monitoring and Forecasting in the Gulf of Mexico - 02/17

Harmful Algal Bloom Monitoring and Forecasting in the Gulf of Mexico - 02/17

Harmful algal blooms are a common occurrence in the Gulf of Mexico. Red tide blooms of the neurotoxin producing alga *Karenia brevis* are of particular concern. NOAA's National Ocean Service uses Coast Watch ocean color data along with cell counts and other environmental information to produce a Harmful Algal Blooms Observing System ([HABSOS](#)) and a Harmful Algal Bloom Operational Forecast System ([HAB-OFS](#)).

HABSOS is a combined data product distributed on an ArcGIS powered map. The system serves as a harmful algal bloom data resource for managers, scientists and the public. CoastWatch data available for visualization in HABSOS include chlorophyll-3 day composite data and chlorophyll anomaly data.



CoastWatch chlorophyll 3-day composite viewed on NOAA's HABSOS.



Copernicus Marine Environment Monitoring Service

<http://marine.copernicus.eu/>

- Combined MODIS & VIIRS observations are used for monitoring HABs in:
 - North Atlantic
 - Arctic Ocean
 - Baltic Sea
 - Black Sea
 - Mediterranean Sea

The screenshot displays the Copernicus Marine Environment Monitoring Service (MEMS) website. The header features the European Commission logo and the service name, "COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE", with the tagline "Providing PRODUCTS and SERVICES for all marine applications". A search bar is located in the top right corner. Below the header, a navigation menu includes links for "ABOUT US", "MARKETS & BENEFITS", "NEWS", "SCIENCE & MONITORING", "TRAINING & EDUCATION", "SERVICES PORTFOLIO", and a "SHORT-CUT TO SERVICES" button. The main content area is titled "ONLINE CATALOGUE" and shows search results for "GLOBAL_ANALYSIS_FORECAST_PHY_001_024". The search criteria include "REGIONAL DOMAIN" (All areas), "PARAMETERS" (MLD SSH 3DUV SIT S SIUV SIC T bottomT), "TEMPORAL COVERAGE" (From 1992-01-01 to 2017-08-26), and "PRODUCT WITH DEPTH LEVEL". The results show two products: "GLOBAL_ANALYSIS_FORECAST_PHY_001_024" and "GLOBAL_ANALYSIS_FORECAST_BIO_001_014". Each product entry includes a description, model details, and a thumbnail image. The footer contains logos for the European Union and Copernicus, along with links for "ABOUT US", "PARTNERS & STAKEHOLDERS", "BENEFITS", and a "ANY QUESTIONS?" button.

COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE
Providing PRODUCTS and SERVICES for all marine applications

Search terms OK

ABOUT US | MARKETS & BENEFITS | NEWS | SCIENCE & MONITORING | TRAINING & EDUCATION | SERVICES PORTFOLIO | SHORT-CUT TO SERVICES

Home > Services portfolio > Access to products

ONLINE CATALOGUE CATALOGUE PDF FIRST VISIT? MY CART 0 My Account

YOUR SEARCH ?

TYPE YOUR SEARCH

REGIONAL DOMAIN ▶
All areas

PARAMETERS ▶

TEMPORAL COVERAGE
From 1992-01-01 To 2017-08-26
☐ If checked, the search results will only show products containing the whole selected time range

PRODUCT WITH DEPTH LEVEL ☐

Found 151 products matching your criteria.

GLOBAL_ANALYSIS_FORECAST_PHY_001_024
GLOBAL OCEAN 1/12° PHYSICS ANALYSIS AND FORECAST UPDATED DAILY

MODEL: ● ● ● ● ● X X X X X
MLD SSH 3DUV SIT S SIUV SIC T bottomT ⓘ
0.083 degree x 0.083 degree (50 depth levels)
From 2006-12-27 to Present
daily-mean, hourly-mean

MORE INFO ADD TO CART WMS Sub-setting

GLOBAL_ANALYSIS_FORECAST_BIO_001_014
GLOBAL OCEAN BIOGEOCHEMISTRY ANALYSIS AND WEEKLY FORECAST

MODEL: ● ● ● ● ● X X X X X
CHL O2 NO3 PO4 SI PHYC FE ⓘ
0.5 degree x 0.5 degree (50 depth levels)
From 2012-01-01 to Present

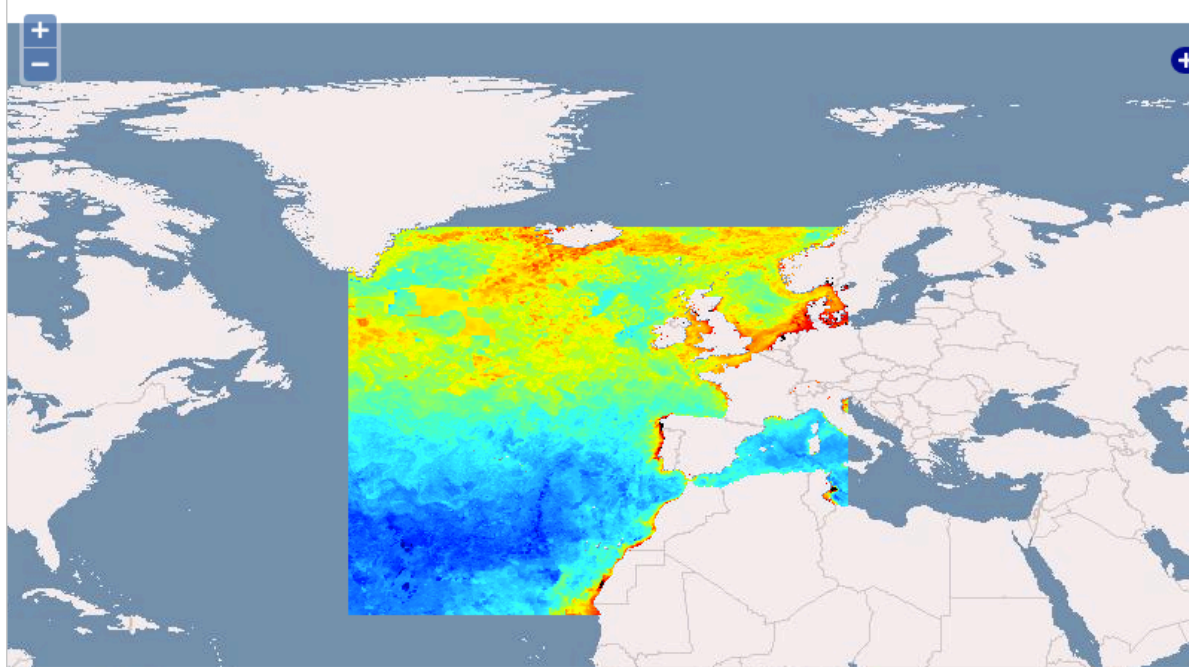
ANY QUESTIONS? Get help from the Service Desk



Near Real-Time Algal Bloom Monitoring Services in the North Atlantic

<http://hab.nersc.no/>

 Near Real-Time Algal Bloom Monitoring Service for North Atlantic



The latest weekly average of chlorophyll-a surface concentration and sea surface temperature from Copernicus Marine Environmental Service ([CMEMS](#)). Select layers in the upper-left corner of the map.

Select date: **2017-08-14**

- Based on ocean color data from Copernicus Marine Environment Monitoring Service





Demonstration of Web-Based Tools for Water Quality Data Access

Chl-a and SST Data Access for HAB Monitoring

- These tools enable data search, spatial and temporal subsetting, analysis, and visualization:
 - OceanColor Web: <https://oceancolor.gsfc.nasa.gov/>
 - Giovanni: <http://giovanni.gsfc.nasa.gov/giovanni/>
- Image Processing and Visualization Software:
 - SeaDAS: <http://seadas.gsfc.nasa.gov/>





Thank You



Breakout Group Questions

Questions

1. Are you using any remote sensing information?
2. Are you focusing more on coastal or inland estuaries?
3. In addition to HABs, what other parameters are you looking for? What water parameter are you most concerned about?
 - a) e.g. turbidity, nutrients, sediments, salinity, SST
4. What kind of decisions do you have to make?
 - a) e.g. water intake, changing agricultural practices.
5. What time frame (weekly, daily) are you making decisions on?
6. Do you have access to in situ data that you can combine with remote sensing? (Is that something you would like to learn?)





Extra Slides

Landsat Bands

Landsat 7 ETM+

Band	Band Range (μm)	Spatial Resolution (m)
1	0.45 – 0.515	30
2	0.525 – 0.605	
3	0.63 – 0.69	
4	0.775 – 0.90	
5	1.55 – 1.75	
6	10.4 – 12.5	60
7	2.08 – 2.35	30
8	0.52 – 0.9	15

Landsat 8 OLI

Band	Band Range (μm)	Spatial Resolution (m)
1	0.433 – 0.453	30
2	0.450 – 0.515	
3	0.525 – 0.60	
4	0.630 – 0.680	
5	0.845 – 0.885	
6	2.10 – 2.30	15
7	0.500 – 0.680	
8	2.08 – 2.35	30
9	1.36 – 1.39	30

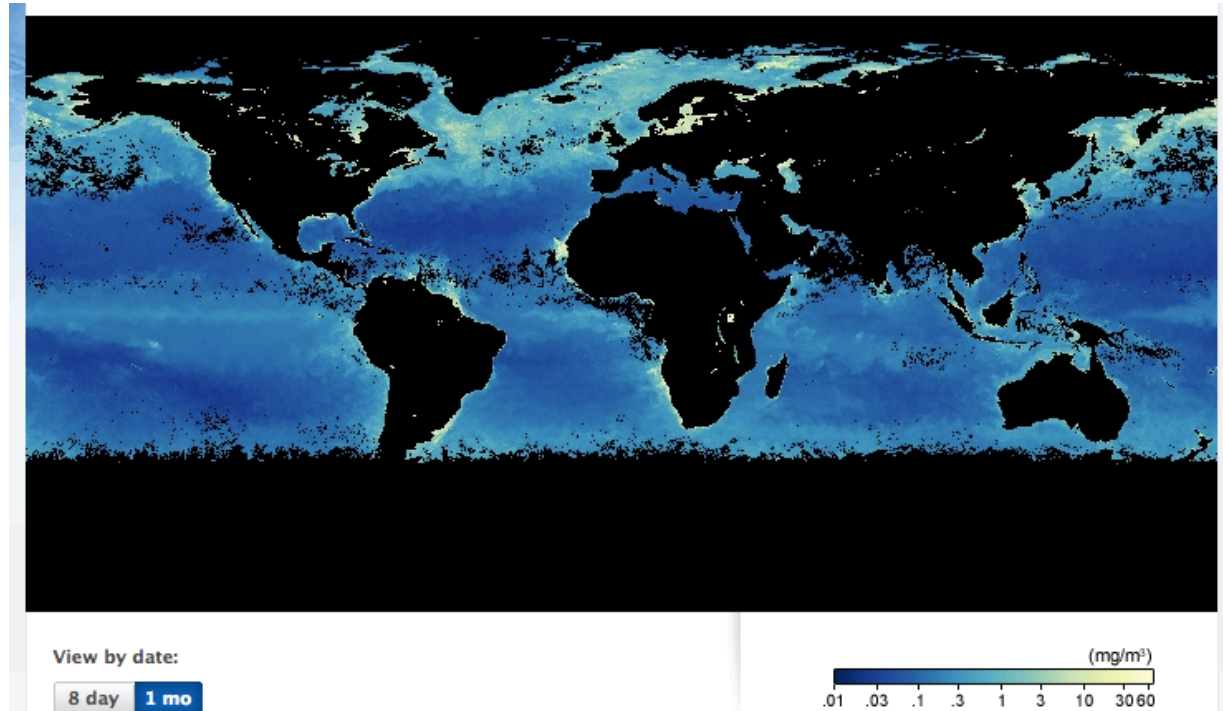


MODIS Bands Relevant for HAB Monitoring

Band	Band Range μm
8	0.405-0.420
9	0.438-0.448
10	0.483-0.493
11	0.526-0.536
12	0.546-0.556
13	0.662-0.672
14	0.673-0.683
15	0.743-0.753

Spatial resolution: 1 km

Chlorophyll Concentration from Aqua
MODIS, June 2017

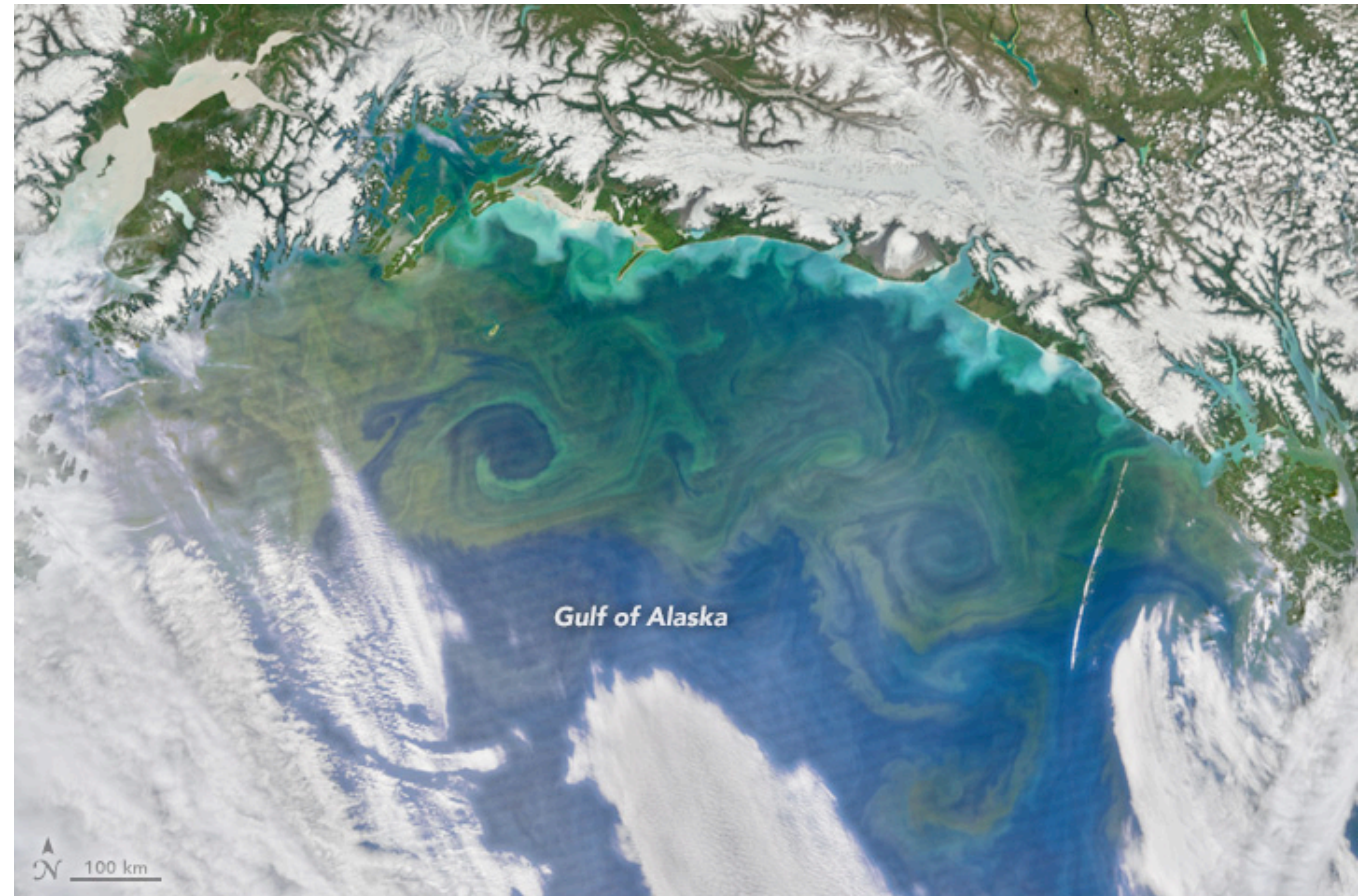


VIIRS Bands Relevant for HAB Monitoring

Phytoplankton Bloom in the Gulf of Alaska, from VIIRS, June 9, 2016

Band	Band Range μm
M1	0.402-0.422
M2	0.436-0.454
M3	0.478-0.488
M4	0.545-0.565
M5	0.662-0.682
M6	0.739-0.745

Spatial Resolution: 750 m

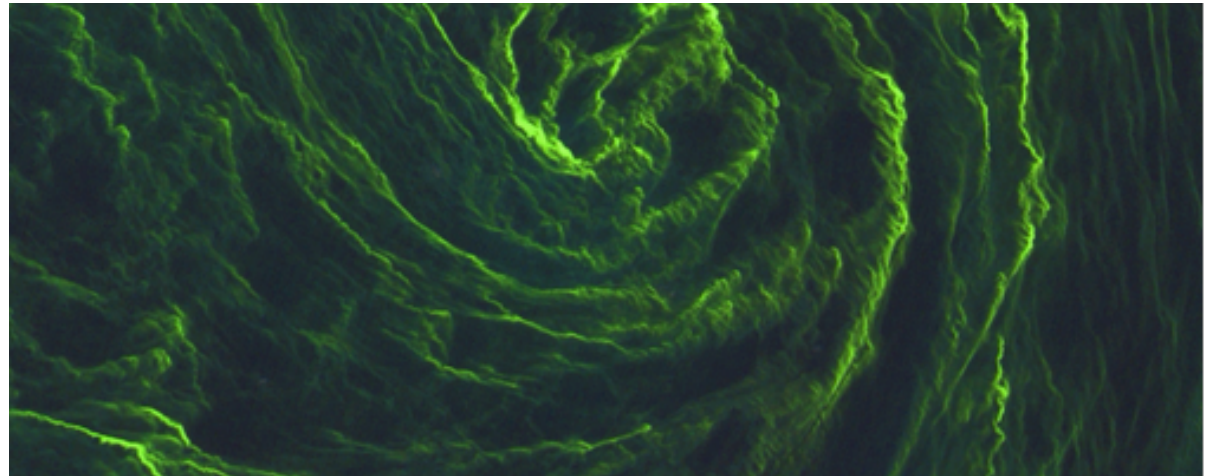


MSI bands

<https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi>

	S2A		S2B		
Band Number	Central wavelength (nm)	Bandwidth (nm)	Central wavelength (nm)	Bandwidth (nm)	Spatial resolution (m)
1	443.9	27	442.3	45	60
2	496.6	98	492.1	98	10
3	560.0	45	559	46	10
4	664.5	38	665	39	10
5	703.9	19	703.8	20	20
6	740.2	18	739.1	18	20
7	782.5	28	779.7	28	20
8	835.1	145	833	133	10
8a	864.8	33	864	32	20
9	945.0	26	943.2	27	60
10	1373.5	75	1376.9	76	60
11	1613.7	143	1610.4	141	20
12	2202.4	242	2185.7	238	20

Algal Bloom in the Middle of the Baltic Sea,
Sentinel-2 MSI, Aug 7, 2015



Copernicus data (2015)/ESA



OLCI Bands

<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci>

Band	λ centre (nm)	Width (nm)
Oa1	400	15
Oa2	412.5	10
Oa3	442.5	10
Oa4	490	10
Oa5	510	10
Oa6	560	10
Oa7	620	10
Oa8	665	10
Oa9	673.75	7.5
Oa10	681.25	7.5
Oa11	708.75	10
Oa12	753.75	7.5

Band	λ centre (nm)	Width (nm)
Oa13	761.25	2.5
Oa14	764.375	3.75
Oa15	767.5	2.5
Oa16	778.75	15
Oa17	865	20
Oa18	885	10
Oa19	900	10
Oa20	940	20
Oa21	1 020	40

Sentinel-3 OCL-Based Chlorophyll Concentration

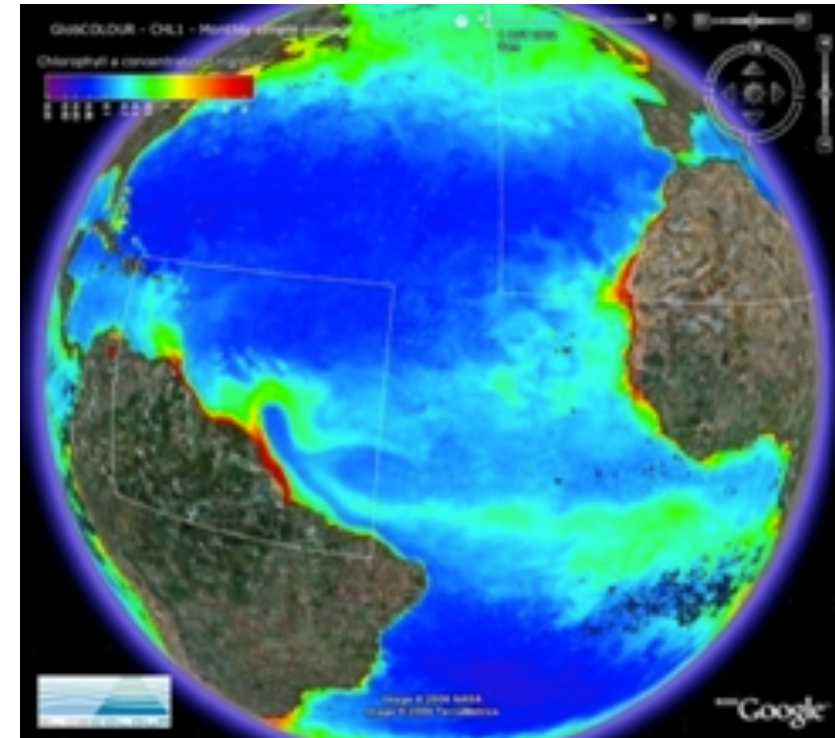


Image Credit: ESA/ACRI-ST



Lake Clarity from Landsat in Wisconsin

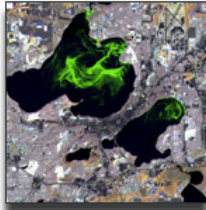
<https://www.lakesat.org/>



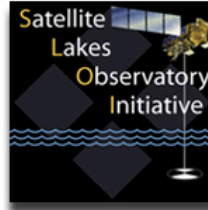
Lake Water Clarity Monitoring and Analysis With Satellite Remote Sensing at the University of Wisconsin-Madison



Field Spectroradiometry
Online library of **lake reflectance spectra**



Statewide Wisconsin Lake Clarity
Landsat Imagery
Results of first Statewide Composite Mapping



SLOI (historical)
Volunteer Network
Information Technical Center

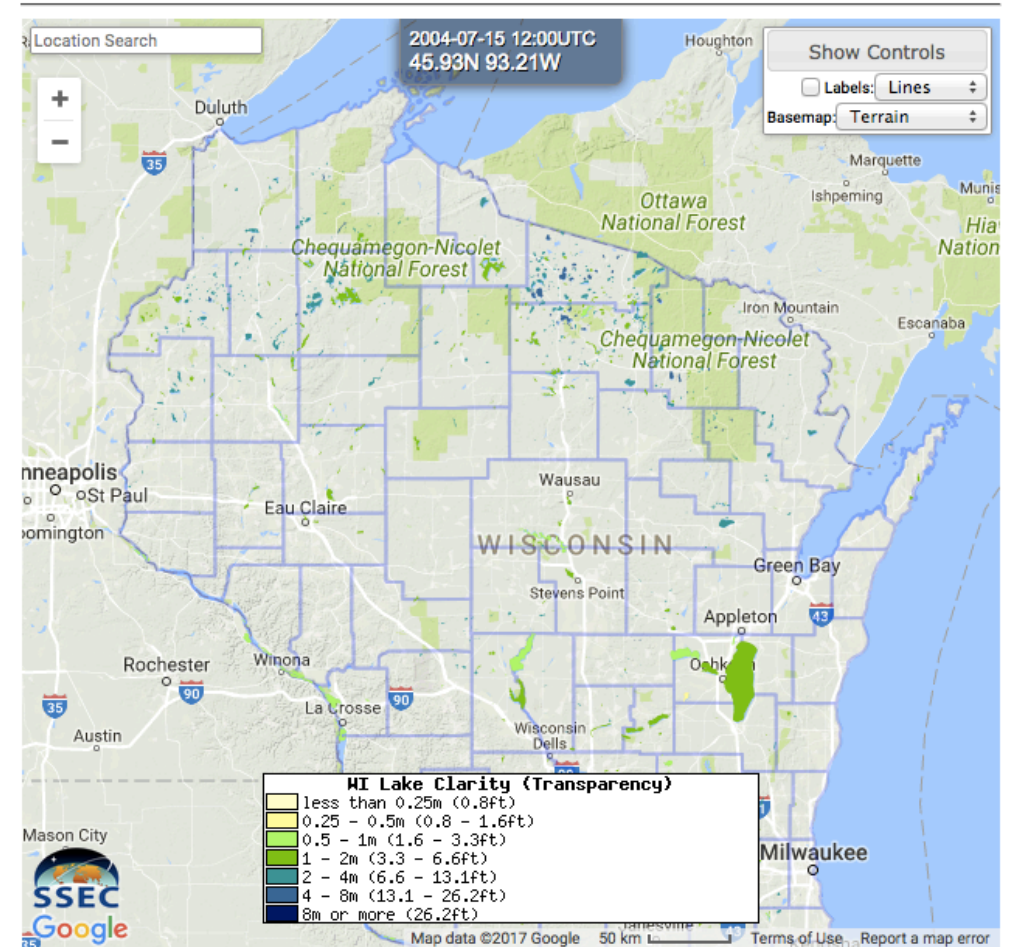


Wisconsin-Today Imagery
SSEC MODIS-Today
Daily **MODIS Imagery**
of Wisconsin and the United States

Visitors since January 10, 2003

[LakeSat Home](#) :: [Field Spectroradiometry](#) :: [Statewide Lake Clarity](#) :: [SLOI](#) :: [MODIS Server](#) :: [ERSC](#) :: [UW-Madison](#)

Environmental Remote Sensing Center :: University of Wisconsin-Madison
1225 W Dayton St, Floor 12 :: Madison, WI 53706
LakeSat Questions: [Sam Batzli](#)



Two dates are available: 2000, and 2004. Use your keyboard's left and right arrow keys to move between them.



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